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AN IN-PLACE POLLUTANTS STUDY OF THE OTONABEE RIVER AND RICE LAKE

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SUMMARY

A 1987 sediment and benthic survey of the Otonabee River and Rice Lake has identified potential concerns associated with point source discharges of contaminants in Peterborough. The major findings are summarized below.

1. Bottom water analyses showed no discernible concentrations of contaminants other than those associated with the Peterborough Sewage Treatment Plant discharge. The study also indicated that release of sediment-bound contaminants to the water column was not a major concern.

2. Concentrations of metals in the sediments were high throughout the system. Concentrations of copper, lead and zinc increased above upstream levels at Peterborough, and again in Rice Lake. A number of sources are likely contributing to these elevated levels. Deposition of suspended material in Rice Lake from upstream sources is the major contributing factor to higher sediment contaminant concentrations in the lake.

3. Concentrations of PCBs in river sediments were very high at Peterborough and decreased further downstream. Concentrations were high in Rice Lake, suggesting that material from upstream has been carried downstream and deposited in the deeper parts of the lake. Concentrations in benthic organisms were generally low and could not be specifically related to sediment sources, though other studies, e.g., clams, have shown that tissue residues reflect the sediment distribution of PCBs. The hydrophobic nature of PCBs suggests that availability from the sediments would be low and that the water column as well as ingestion of contaminated food sources may be the most significant routes of uptake for PCBs.

4. Sediment PAH concentrations were very high in Peterborough and decreased rapidly downstream. While sources can not be determined an old coal gasification complex in Peterborough as well as urban runoff are among possible sources that would warrant investigation.

5. Tissue residues of contaminants in benthic invertebrates and fish were low for metals and generally below detection limits for organic compounds (PAHs were not analyzed) other than PCBs and indicate that most compounds were present in the sediment in unavailable forms. Little or no bioaccumulation could be attributed directly to sediment sources.

6. Sediment bioassays indicated that there was no acute toxicity from sediment associated contaminants, though mortality and uptake of some contaminants (mainly metals) was higher at certain stations.

7. Benthic community response suggests that the deposition of organic matter is the single most important factor affecting benthic invertebrate distribution. No clear impact of contaminants could be detected on the benthic community.

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1. INTRODUCTION

A history of past discharges and spills of PCBs from various industries located along the Otonabee River in Peterborough prompted the Ministry of the Environment to undertake an investigation of the sediment, water and biological compartments to determine the fate and effects of these contaminants in the river. Samples from Rice Lake indicated that a number of contaminants had found their way into the lake as well. As a result, a detailed study was launched in 1987. This report presents the results of the assessment of sediments and associated sediment fauna in relation to contaminant distribution.

2. METHODS

In June of 1987, fifteen stations were surveyed along the Otonabee River and Rice Lake at, and downstream of, the City of Peterborough. Control stations were located upstream of Peterborough while the downstream stations were located as far as Rice Lake and the Trent River (Fig 1).

Bottom-water samples were collected 1 m off the bottom with a Van Dorn sampler on the last day of each field survey, properly preserved according to the type of analysis required and submitted to the MOE laboratory. Samples were analyzed for nutrients, ions, metals, PCBs, organochlorine pesticides and chlorinated aromatics.

Sediments were collected using a 9" x 9" (22.9 cm x 22.9 cm) stainless steel Ponar grab sampler. One Ponar sample was collected at each station for sediment analysis. Sample jars were filled with the top 5 cm of sediment from the Ponar. Most physical measurements were carried out in the field in accordance with the methods described in Persaud *et al.* (1987) and included sediment pH, redox potential, and sampling depth. Sediments were maintained at 4 C until analyzed.

Chemical analyses on sediment and bottom water were carried out in the MOE laboratory in accordance with procedures described in OMOE (1983). Sediments and bottom water were analyzed for nutrients, metals, PCBs and pesticides, PAHs, chlorinated aromatics, as well as sediment particle size.

Benthic organisms for contaminant analysis were also collected by Ponar sampler. A minimum of 2 gms of the most abundant organism was collected at each station for inorganic contaminant analysis, wrapped in plastic and immediately frozen. An additional 4-5 gms was collected for organic contaminant analysis, wrapped in hexane rinsed foil and frozen. These were analyzed for PCBs and pesticides, PAHs and chlorinated aromatics as well as percent lipid content and ash. The percent ash was used to correct for gut content in determining tissue metal concentrations. Analyses were carried out by consultant laboratories according to the methodologies described in Persaud *et al.* (1987) and OceanChem (1988).

The most abundant bottom-dwelling fish (sculpins) were collected in an effort to gain an understanding of contaminant transfer between the various compartments (e.g., sediments, benthos, water, fish). Sculpins (6-10 cm total body length) were collected by divers equipped with handnets from the closest suitable substrate at each station location. At each station a minimum of 15 sculpins were collected for tissue analysis. Sculpins from each station were grouped by species, age and length. The analyses were the same as those for benthic invertebrates.

A total of 5 replicate samples for benthic invertebrate community analysis were collected at each station using a Ponar grab sampler. Samples were field washed using a U.S. 30 mesh (595 um) sieve and the residue was preserved in containers of 5-10% neutralized (with borax) formalin solution. Samples were sorted under a dissecting microscope. The densities of organisms were averaged over the total number of replicates and the replicate closest to the mean values was chosen for detailed identification of the organisms present. The remaining four samples were set aside for biomass determination. Diversity indices were calculated according to the formulas in Jaagumagi (1989).

Biomass estimates were calculated as preserved wet weight of organisms. Samples were blotted dry on filter paper to remove surface moisture and were immediately weighed to the nearest 0.1 mg on a Mettler H20T balance. The results were averaged over the number of replicate samples and the mean value has been presented in the tables. A correction factor of 10% has been added to the total preserved weight to attain the total live wet weight. Studies by Wiederholm and Eriksson (1977) and Landahl & Nagell (1978) have shown that on average a 10% weight loss occurs in preserved specimens due primarily to differences in

densities between ethanol and water.

Laboratory sediment bioassay experiments were conducted on material collected from the Otonabee River and Rice Lake in June, 1987. One sediment sample was collected per station from all 14 stations shown in Figure 1.

Sediments were transported to the MOE Rexdale laboratories, where they were stored at 4 C. Part of the sediments collected were used for analysis of the same parameters measured in July. On November 20, 1987, the sediments were sieved through a 3 mm mesh sieve prior to use in the bioassay. A total of 200 mL of sieved sediment was placed in a 1 L Mason jar to which was added 800 ml of dechlorinated tap water. Six jars were filled for each station and the sediments were allowed to settle for 24 hrs. before aeration was started. After 1 hr of aeration, test animals were added to the jars. The six test jars for each station were divided into two groups of three jars each. Five fathead minnows (*Pimephales promelas*) were added to each of the three jars in the first group and five nymphs of the burrowing mayfly *Hexagenia limbata* were added to each of the three jars in the second group. The minnows used were cultured in the MOE Rexdale laboratory and were all 3 months of age. The mayflies were second year nymphs collected at Honey Harbour (an uncontaminated site) on Georgian Bay. Honey Harbour sediments were used for the experimental control.

The bioassay was run for a total of ten days in a controlled water bath at 20 C and was monitored daily during this time for any mortality at which time any dead animals were removed. In addition, pH and dissolved oxygen of the overlying water were measured daily. At the end of the ten day period the surviving animals were removed, frozen, and subsequently submitted for analysis of tissue contaminant levels. In order to obtain sufficient biomass for tissue analysis, the surviving mayflies from all three replicates were pooled. One replicate for fathead minnows (greatest number surviving) was selected for analysis.

3. RESULTS

3.1 Water

Bottom water was collected at all stations sampled for sediments and biota in 1987. The results are presented in Tables 1 through 4.

The Rice Lake-Otonabee River system can be characterized as a moderately hardwater stream (alkalinity ranged from 90.1 mg/L in Rice Lake to 107.8 mg/L (as $CaCO_3$) below the STP outfall at station 0004). The numerous storm sewer discharges located along the river in Peterborough appear to have had no discernible effect on the water quality at the time of sampling. The STP discharge located near station 0004 does appear to have an effect on the water quality, mainly in the slight increase in ammonia, conductivity, sodium, chloride, phosphorus and nitrates (Table 1). Higher levels persisted in the river as far as the mouth of the Otonabee River at Rice Lake. Levels in Rice Lake, though lower than levels at station 0004, were higher than in the control area of the Otonabee River (stations 0002 and 0015) and indicate the effects persisted into Rice Lake.

Concentrations of heavy metals in the water were generally low with a number of parameters (copper, chromium, cadmium, arsenic and nickel) below detection limits (Table 2). Concentrations of the other metals, though at detectable levels, were low and concentrations in Rice Lake were generally higher than in the Otonabee River. Water concentrations do not show any indication of local sources of input.

Water concentrations of organics, PCBs and pesticides were all below detection limits (Tables 3 and 4).

3.2 Sediments

Sediments are often the primary reservoir for contaminants discharged in effluents. Most metals and organic compounds tend to bind or partition to organic particles in the water column and subsequently settle to the bottom (Sigg *et al.* 1987; Smith *et al.* 1988). The distribution of contaminants in sediments is therefore the sum product of effluent concentrations (from all effluent sources), current and wave action, suspended particle concentration and sorption characteristics.

Distribution and organic content of the fine-sediments are probably the most important factors affecting contaminant distribution within an area. Substrates in the Otonabee River were mainly sand, with variable amounts of silt (Table 5). Silt content ranged from a high of 58.7% at station 0002, the upstream control, to a low of 9.2% (87% sand) at station 0004. Stations 0002 and 0003 were the only stations in the river where sand content was

below 50%. Sediments in Rice Lake were mainly an organic ooze and could not be analyzed for grain size, with the exception of station 0009. At that station sand and silt comprised an almost equal mix. Station locations are shown in Figures 1 and 1a.

METALS

Sediment TOC was high at all stations (Table 6). Concentrations were very high in Rice Lake, likely as a result of the organic ooze that formed much of the substrate in the lake. The lowest TOC concentration was at station 0004, in an area of mainly sandy substrate. Despite the high levels of sediment organic matter at all stations, concentrations of most metals were relatively low. Sediment metal levels in general correlated poorly with sediment TOC. The implications are that the accumulation of metals in sediments was more or less independent of the accumulation of sediment organic matter, since those areas with substantial accumulations of organic matter did not show corresponding increases in sediment metal concentrations. This suggests that metals were associated more closely with specific sources in the system.

Sediment concentrations of arsenic, cadmium, and mercury (Fig 2b) and also chromium (Fig 2a) were highest in Rice Lake (Table 6). The deposition of organic matter in the lower energy environment of the lake would tend to favour the accumulation of contaminated suspended matter carried down from upstream areas.

Concentrations of most of the metals increased from station 0001 (at the Rink Street Drain) to station 0003 (in Little Lake) and despite a drop at the downstream stations 0004 (below the Hwy 7 bridge) and 0005 (at Bensfort Bridge) (both of which were sandy, erosional areas), remained relatively high into Rice Lake (Fig. 2; Table 6). Sediment concentrations at station 0001 were similar to station 0003, despite the higher organic content at station 0003. Concentrations of copper, lead and zinc were higher at stations 0001 and 0003 than at upstream locations (stations 0002 and 0015) and were also higher than areas further downstream (stations 0004 and 0005). Sediments at station 0004 were similar to station 0001 (80-90 % sand) though both organic content (as TOC) and metal concentrations were lower at station 0004. It appears that some metal contamination has occurred at station 0001. Copper, lead and zinc sediment concentrations were also higher at station 0003 than at station 0002, the upstream control corresponding most closely in sediment type (silt and TOC were higher at station 0002, which theoretically, should favour a higher accumulation of metals). The most likely possible sources of these increased and sustained high concentrations may be the storm sewers flowing into the Otonabee River in the area of stations 0001 and 0003 (Figure 1a), though the relatively high upstream sediment concentrations of many metals suggests that the river already carries a high background level. Sediment concentrations of mercury were high at all stations in Rice Lake but levels were generally lower in the Otonabee River.

A considerable increase in sediment concentrations of solvent extractables occurred at station 0001 (Table 6) where concentrations were approximately 3.5 times higher than at station 0002 and nearly 12 times higher than at station 0015 (the controls). Sediment concentrations were also high at station 0003, though concentrations did decrease to near upstream levels by station 0004. Concentrations in Rice Lake were also considerably higher than at station 0015, and in nearly all cases exceeded the MOE open water disposal guideline of 1500 $\mu g/g$. Sediment concentrations at station 0011, at the eastern end of Rice Lake were the higher than at any of the other stations in the study area. Upstream sediment concentrations were also high and suggest a generally high level of contamination exists throughout this section of the river. This may be due to the high density of boat traffic in the Trent system and the general proliferation of marinas associated with this traffic. Despite the high background levels, sediment solvent extractable concentrations do increase considerably below the storm sewer discharges above Little Lake and these appear to be contributing factors to the high sediment concentrations. No strong relationship could be determined between sediment solvent extractables and metal concentrations in the sediment. While significant correlations were obtained between lead, zinc, arsenic and nickel concentrations and solvent extractables, these relationships were not strong (Table 21). No significant correlations were obtained with solvent extractables and either PCBs or PAHs.

METAL GEOCHEMISTRY

Metals will often bind preferentially to different components of the sediment. The sequential extraction scheme is an operationally defined process that separates the various components in the fine-particle (<63 u) fraction. The concentration of metals can be measured in

each of the following geochemical phases:

IW - Interstitial Water
F1 - Cation Exchangeable Fraction
F2 - Easily Reducible or Carbonate Bound
F3 - Organic Complex
F4 - Fe/Mn Oxide Fraction
Res- Residual Fraction

The significance of each fraction and the extraction procedure are discussed in Persaud *et al.* (1987) and Tessier (1979). The results of the geochemical extraction procedure are presented in Table 7 and Figure 3.

Aluminum occurred mainly in the residual fraction with a smaller amount in the F3 (organic/sulphide bound) fraction (Figure 3a). Total aluminum concentration was highest at upstream locations (stations 0002 and 0015), though the residual fraction remained the major repository of sediment aluminum.

Geochemical distribution of arsenic (Table 7 and Figure 3b) shows that the largest concentrations were found in the F3 and F4 fractions in the Otonabee River. A significant increase in the Residual fraction was also observed at station 0001. In general, concentrations were higher in the Otonabee River than in Rice Lake. Large amounts were held in the organic fraction in Rice Lake and this is not surprising, given the very high concentrations of organic matter in the lake.

Cadmium concentrations showed only slight variation among the various geochemical fractions (Fig 3c). Concentrations in the organic fraction were higher at station 0003 and were highest at station 0004, which may be reflective of storm sewer and STP inputs in this area of the river.

Chromium concentrations showed the largest increases in the F3 fraction beginning at station 0001, with a peak at station 0004 (Fig 3d). The storm sewers and the STP could both be contributors to higher sediment levels in this area of the river.

Copper concentrations increased mainly in the F3 fraction at station 0001 (Fig 3e). Levels were highest at this station and decreased slightly at stations 0003 and 0004. Downstream, levels were near those in the upstream control areas.

Iron concentrations showed the greatest amount of variation in the residual fractions among the stations in the Otonabee River (Fig 3f). Concentrations in the other fractions were consistently lower and showed little variation among the stations. Levels increased again at station 0014 in Rice Lake, probably as a result of deposition of material carried by the river.

Lead concentrations were substantially higher in the F3 fractions at stations 0001, 0003, and 0004 (Fig 3g). Lead was also higher in the F4 fraction at station 0001. The large increase at station 0001 suggests that local inputs, most likely the storm sewers draining to the river, have contributed higher levels of lead to the sediments. The presence of the lead in the F3 fraction suggests that this material has been deposited recently.

Sediment concentrations of manganese were higher in the F1, F2, F3 and residual fractions at stations in the Otonabee River (Fig 3h). A significant increase was also observed at station 0014 in Rice Lake, likely as a result of the deposition of suspended material from the Otonabee River.

Nickel concentrations in the F1, F3 and Residual fractions were higher in the Otonabee River than in Rice Lake (Fig 3i). No significant increase in sediment concentrations was noted downstream of the control station (0002) and levels in the river probably reflect the background levels.

Zinc was highest in the F3 sediment fraction at station 0001, 0003 and 0004 (Fig 3j). Like lead, the levels probably reflect the input of storm sewers in this area of the river. The increase in the organic fraction suggests that the metal here is of relatively recent origin. Levels were low in Rice Lake, with a minor increase at station 0014.

The distribution of metals in the Otonabee River appears to be related to sources of local input. The storm sewers and secondarily, the STP, appear to be contributing increased levels of most of the metals to the sediments in this area of the river. The levels were often highest at station 0004, where sediment organic content was lowest, suggesting a significant source in this area.

ORGANICS

Organic contaminants (chlorinated aromatics and organochlorine pesticides) were usually found at or below detection limits (Tables 8 and 10). PCBs however, showed a significant increase in sediment concentration at station 0003 (Table 8; Fig 5), indicating that a substantial source lies upstream between station 0001 and 0003. A

clam uptake study has implicated the Rink St Drain as one source of PCBs (A. Hayton (OMOE), Pers. Comm.). Due to the flow regime of the river, contaminants lost or discharged to the river could be carried for some distance downstream before settling to the sediments and may account for the relatively low sediment concentrations at stations 0001 and 0003. The highest sediment PCB concentrations were observed at station 0004. Since the substrate at station 0004 was predominantly sand and low in organic matter this concentration is very high. Availability of PCBs from sediment to biota has been found to be controlled primarily by organic matter (Smith *et al.* 1988). Consequently, sediments low in organic matter are less effective at binding contaminants, with the result that these can be more readily sorbed to biological tissues, or back into the water column. Therefore, the low organic matter content of the sediments at station 0004, coupled with the high PCB concentration has implications for biota uptake of PCBs as well as for desorption from the sediments to the water column.

PCBs were found in sediments at above detection limits downstream into Rice Lake and high concentrations persisted in sediments as far as station 0013, in the Trent River. Sediment concentrations in Rice Lake were higher at the western end near the mouth of the Otonabee River and decreased towards the eastern end. No correlation between sediment accumulation of PCBs and organic matter (as TOC) could be found. Studies by Ferguson and Metcalfe (1989) suggest that PCB contaminated sediments at Peterborough are resuspended and carried downstream to Rice Lake during periods of high discharge.

Both spills of PCB contaminated oils and intermittent discharges have been suggested as possible sources of the PCBs (Ferguson and Metcalfe 1989; A. Hayton (OMOE), Pers Comm.).

Sediment concentrations of all PAH compounds were very high at station 0001 and decreased markedly downstream (upstream controls were not analyzed for PAHs)(Table 9; Fig 4). Station 0001 had the highest concentrations of all the PAH compounds included in the analysis (in particular phenanthrene, fluoranthene and pyrene). All of the compounds that exhibited higher sediment concentrations at station 0001 are typical constituents of oils and coal tar (CCME 1989). Sediment concentrations were significantly lower at station 0004 and continued to decrease rapidly further downstream in the Otonabee River and into Rice Lake as distance from the apparent source increased. Sediment PAH concentrations were negatively correlated with sediment organic matter (in some cases significantly, Table 22) which suggests that sediment accumulation of PAHs is due to discharge from a specific source and is not specifically associated with sorption and deposition with organic matter.

The source of the PAH compounds is cannot be determined, since upstream sediments were not analysed for PAHs. However, storm sewer discharges are one possible source of PAHs. Discharges of oils through the Romaine Street sewer, which discharges in the area of station 0003, have been recorded in the past (A. Hayton (OMOE), Pers. Comm.). The high levels of solvent extractables at station 0001 suggests that a considerable quantity of oils or oil-like substances are still present in the sediment and storm sewers in this area may be a possible source. The source however can not be determined with certainty since no upstream stations were analyzed for PAHs. It is also possible that the PAHs may be related to the past operation of a coal gasification plant that operated in Peterborough from the mid-1800's to the 1950's. The source of the PAHs warrants further investigation.

3.3 Biota Contaminant Residues

3.3.1 Benthic Invertebrates

The geochemical distribution of metals in the sediment can directly influence the availability of the metals to aquatic organisms. Studies (Luoma 1983; Smock 1983) have suggested that 80 to 85% of an organisms body burden may be acquired by adsorption of metals through the integument or cuticle (Knowlton *et al.* 1983) and that the free ion concentration in the interstitial water is usually the most available phase. However, sediment concentrations may contribute up to 20% of body burden, depending on the availability from the sediments. Luoma (1989) notes that for each metal there exist sediment bound forms that can be accumulated through ingestion of sediment, but that forms also exit that show little availability when ingested. Nalepa & Landrum (1988) have noted that while free metals are readily available for uptake, they tend to complex very strongly with the organic fraction in sediments and water, which limits their availability, at least in those cases where organic content of the water or sediments is high. Luoma (1989) notes however, that while metal assimilation from ingested particles is much less efficient than

from free ions in solution, the source in the former case is much more concentrated and thus may contribute greater amounts to an organisms body burden than adsorption. Nalepa & Landrum (1988) have observed that most metals require an active or facilitated process for assimilation and that accumulation is therefore most likely from sediments via ingestion. Luoma (1983) however, noted that only for those metals considered essential micronutrients (zinc and to some extent, copper) did tissue levels appear to behave independently of environmental concentrations. Clearly, the most important factors controlling uptake seem to be those governed by local conditions - i.e. organic matter content of the sediment and the presence of scavenges compounds such as the iron and manganese oxides and hydroxides.

Uptake of nonpolar organic compounds by organisms also appears to be relatively complex, despite the near singular attraction of these compounds to sediment organic matter. Availability of the less hydrophobic compounds would appear to be highest, since the relatively greater amounts available in the water (and this includes the sediment interstitial water) would suggest that these compounds could be accumulated to relatively high levels in tissues. Nalepa & Landrum (1988) have suggested that the predominant route of uptake of organic compounds appears to be through passive diffusion from the aqueous phase, generally across the integument or respiratory surface.

Sorption of contaminants to sediments and desorption to the water phase are believed to be continuous exchange processes (Stumm & Morgan 1981). Levels of metals and organic compounds available to biota from the water phase would therefore depend on levels available in the solid phases of the sediments. As such, in areas of contaminated sediment, even minute concentrations in the interstitial water or bottom water could contribute significantly to an organisms body burden through a more or less continuous availability of the contaminant. This depends mainly on ease of desorption from the solid fractions to the interstitial water, which appears to be the main medium of uptake by aquatic organisms (Luoma 1983; McElroy *et al.* 1989).

Metals held in the solid fractions (F1 to F4) are generally considered to be potentially available to aquatic organisms (Persaud *et al.* 1987). Availability decreases somewhat from the F1 to the F4 fraction as binding strength to the sediments increases and reflux potential to the water (mainly the interstitial water) decreases. Metals bound to the F4 fraction (Fe/Mn oxides/hydroxides) are usually unavailable except under reducing conditions (Stumm & Morgan 1981). Similarly, metals held in the organic fraction are also relatively tightly bound and not easily removed under the gut conditions of most benthic organisms (Luoma 1983). This means that metals held in the F1 to F3 fractions are usually the most available to benthic organisms, since these are the most readily extractable.

Metals held in the residual fraction are usually not available to benthic organisms nor do they readily reflux to the water. These are the most tightly held metals since they are bound within the crystal lattices of minerals (clays etc) and are not available under natural conditions.

Since in the case of metals 15-20% of an organisms body burden can be acquired through ingestion of contaminated sediments, the presence of contaminants in the more readily available fractions could serve to facilitate uptake and tissue concentration by means of digestive processes. The presence of metals in these fractions could also serve to increase the availability of these metals in the interstitial water.

METALS

Benthic invertebrate tissue metal concentrations, expressed on a dry weight basis and corrected for gut contents using a standard correction factor, shows that accumulation in tissues to levels higher than in sediments occurred at only a few stations and for only a few metals (Table 11: Fig 6). Since no data exists for upstream control stations, tissue concentrations can only be compared between Rice Lake stations and the downstream stations in the Otonabee River (Table 12). Metals were generally less available from the sediments at station 0003, where chironomid tissue concentrations were higher than sediment levels only for arsenic. Tissue concentrations exceeded sediment concentrations at station 0004 for copper, mercury, cadmium, lead, zinc and manganese despite the lower bulk sediment concentrations of these metals (with the exception of lead) at station 0004 as compared to station 0003. The sediment characteristics differed between the two stations, with sandy sediments prevailing at station 0004 while silt content was much higher at station 0003. The affinity of metals for organic particles has been shown in other studies (Sigg *et al.* 1987; Luoma 1989) to significantly limit their availability to aquatic organisms.

Accumulation of the metals copper, mercury, cadmium, lead and zinc in tissues was also high in the mayflies collected at station 0005 (Table 12). No comparable data are available for chironomids from this station, though, bioaccumulation factors were considerably higher in the mayflies than in the chironomids at station 0004 for zinc, copper and mercury despite considerably lower sediment concentrations at this station. Concentrations in the F3 fraction of the sediments were also much lower at station 0005, suggesting that some of the tissue residue in the mayflies may have been accumulated over a longer period of time, and from the water column as well as from sediment sources. Mayflies generally have a two-year life cycle in the sediments and thus would be exposed to sediment-bound contaminants for a considerably longer period of time than the chironomids.

In general, the higher sediment metal concentrations in Rice Lake did not result in higher tissue residues in the benthic invertebrates. Tissue residues of arsenic (Fig 6a), lead (Fig 7e) and zinc (Fig 6d) showed substantial decreases in Rice Lake over the levels found in the Otonabee River organisms. In fact, tissue residues in Rice Lake fauna appeared to be lower overall than in the Otonabee River, and are likely due to lower sediment availability due to the higher organic content of the Rice Lake sediments.

While poor correlations have generally been obtained between tissue concentrations and the various sediment fractions in other In-Place Pollutants studies, significant correlations ($P < 0.05$) were obtained for some metals in this study (Tables 21 and 23). (Correlation analysis on the sum of the F1 to F4 fractions was not performed in those cases where concentrations in one or more of the fractions showed no variability - i.e. where concentrations were consistently below detection limits). Tissue cadmium levels were significantly correlated with the sum of the F3 and F4 fractions, though correlations could not be obtained for a number of the other fractions due to invariability of the data (Table 23). Copper in tissue showed the best correlation with concentrations in the sum of the F3 and F4 fractions, though the correlations were relatively weak ($r=O.6503$). Tissue lead concentrations were strongly correlated with concentrations in the sum of the F3 and F4 fractions. Of the individual fractions, the best correlations with tissue levels were obtained with lead in the F3 fraction. Manganese tissue residues correlated best with the concentrations in the F3 + F4 fractions. Tissue residues of aluminum were strongly correlated with the concentrations in the residual fraction and also with the concentrations in the F3 + F4 fractions. Nickel levels in tissues suggested a similar relationship with concentrations in these two levels. No significant correlations were obtained between tissue levels and levels of metals in the bottom water or in the interstitial water. However, in a number of cases, the levels in these media were invariate and thus precluded proper analysis.

ORGANICS

No detectable tissue concentrations of organochlorine pesticides could be found in any of the samples (Table 13).

Some accumulation of PCBs was evident, but tissue residues were found to be highest in chironomids in the upstream control (station 0015) and at station 0012 in Rice Lake. Tissue concentrations in those organisms collected at stations 0003, 0004 and 0009, where sediment concentrations were highest, were very low. Tissue-sediment concentration ratios (Table 11) show that PCBs were concentrated to levels higher than in sediments at stations 0015, 0001, 0005, 0012, and 0013. The highest ratio was obtained for station 0015, where tissue levels were over 100x those in sediments. Accumulation of PCBs by organisms at station 0001 was also higher than sediment concentrations (which were below detection limits). In contrast, tissue-sediment ratios at station 0004, where the highest sediment concentrations were found, had the lowest ratios. Wet weight tissue concentrations in organisms from this station were below detection limits (Table 13). Similarly, while high sediment concentrations were found at stations 0008, 0009 and 0014, tissue sediment concentration ratios were all very low, with actual tissue residues in organisms from two of these stations (0008 and 0014) below detection limits (Table 13). No significant correlation could be obtained between tissue and sediment concentrations ($r=-0.3802$, $P<0.2$).

Sediment characteristics in Rice Lake appear to be more uniform than in the Otonabee River (Table 6), yet there was a large amount of variation in the accumulation of PCBs by organisms in the sediment. It would appear that the elevated levels of PCBs in the sediments at stations both in Rice Lake as well as the Otonabee River are generally unavailable to benthic organisms, perhaps due to binding to sediment components or the

matrix in which the PCBs were deposited. The high tissue concentrations in relation to sediment concentrations at those stations where sediment levels were low suggest that sources other than sediment-bound PCB are more available to these organisms.

These tissue residue studies are not consistent with other studies that have involved water column organisms. Analysis of fish tissues (K. Suns (OMOE), Pers. Comm.) and clam uptake experiments (A. Hayton (OMOE), Pers. Comm.) have both shown a longitudinal distribution of PCB residues in tissues that are similar to the sediment PCB distribution. These results suggest that the water column organisms are obtaining the PCBs primarily from the water column and that sediment-bound PCBs are generally not biologically available.

Tissue concentrations of the other organic compounds were below detection limits (Table 14). Benthic organisms were not analyzed for tissue residues of PAH compounds.

3.3.2 Sculpins

The analysis of the effects of sediment bound contaminants on bottom dwelling fish was hampered by the lack of specimens. Fish were available from only a few locations in the study area and generally were absent from the locations in Rice Lake, most likely due to unsuitable substrate. In general, sampling locations did not coincide precisely with sediment and benthic sampling locations, due to a lack of suitable substrate. The closest area(s) of suitable habitat was (were) sampled in these cases. Sampling locations that did not coincide precisely with station locations are identified in the data tables with a letter suffix (usually "a" or "b").

Sculpin tissue concentrations, for the small number of stations for which data were available, indicate that metals were not being accumulated by the fish to levels higher than in the sediment. While mercury was accumulated in fish tissues to higher levels than in the invertebrates, levels in the sculpin tissues were still below sediment concentrations. Tissue residues of arsenic and copper were similar in both (Fig 7a and 7d), while tissue residues of the remaining metals were lower in sculpins than in the invertebrates (Fig 7b, 7c and 7e).

Metal concentrations in tissues showed only slight longitudinal variation with only small increases in tissue residues in downstream locations. In a number of instances tissue concentrations in fish from the upstream control areas were higher than at downstream locations (e.g. aluminum, chromium, copper, manganese and nickel) (Table 15). Overall, tissue residues were lowest at station 0011 in Rice Lake, though in most cases the levels in fish from the Otonabee River were not substantially different from those in Rice Lake. In general the sediments do not appear to be a major source of metals to the fish since tissue concentrations were generally low.

Tissue accumulation of metals by sculpins and invertebrates was variable, though in general residues were lower in the fish than in benthic invertebrates. However, the essential micronutrients copper and zinc, were accumulated to higher levels in fish tissue than in invertebrates (Fig. 7). Mercury, the only metal for which biomagnification is of concern, was also accumulated to higher levels in fish tissue (Fig 7f). Since the fish are potentially exposed to contaminates from both the sediments (through increased concentrations in the pore water and in their food) as well as from the water column, it is likely that accumulation of these compounds occurs from both these compartments.

Tissue analysis of fish showed that PCBs were accumulated by some fish at stations 0001, 0003 and 0009. Tissue residues are shown in Table 16 and the range of concentrations was similar to that noted for benthic invertebrates (Figure 7h). Tissue concentrations of PCBs in benthic invertebrates were highest at stations 0001 and 0003, where sediment concentrations were low and did not increase at station 0004 where sediment concentrations were highest. This suggests that the water column, either as freely dissolved or bound to suspended matter, was the major source of PCBs and that availability from the sediments is generally low. Numerous studies (Smith *et al.* 1988; Knezovich *et al.* 1987; Chapman 1987) have suggested that sediment organic carbon is the principal factor controlling the availability of nonpolar organic compounds from sediments.

Literature to date indicates that sorption of these compounds is primarily from the dissolved phase and that sediments act principally as either reservoirs for desorption to the water phase (McElroy *et al.* 1989; Smith *et al.* 1988) or as sinks. Desorption from the sediment solid phases would tend to result in increased concentrations in the interstitial water, increasing the potential for biological uptake. For the hydrophobic nonpolar organic compounds, some studies suggest there is growing evidence that food sources may be a

significant uptake route, especially for water column organisms such as fish (Chapman 1987).

Since three potential routes of uptake exist for bottom-feeding fish such as sculpins (i.e., water, sediment and food), the contributions from any single source cannot be determined.

Some detectable concentrations of γ-BHC and pp-DDE were noted in those fish in the Otonabee River, though fish from the control areas generally did not yield detectable levels. Other organic compounds were generally not detected in sculpin tissues (Table 17). Fish were not analyzed for PAH tissue residues.

3.4 Sediment Bioassays

The results of the acute toxicity bioassay are presented below. The percent mortality over the ten day period is shown for both mayflies and fathead minnows. Sediments from station 0002 were not tested and the control station is the experimental control.

Station	Fathead Minnows	Mayflies
Control	0	7
0015	0	13
0001	13	7
0003	0	13
0004	20	20
0005	7	13
0008	20	0
0012	0	13
0006	0	7
0009	13	7
0014	0	7
0007	0	0
0010	0	13
0011	0	27

The results indicate that the sediments were not acutely toxic over the ten-day test period. Mortality of fathead minnows was low except at stations 0004 and 0008. Though no mortality was observed among the mayflies at station 0008, mortality was observed among mayflies at station 0004. This coincided with higher mortality among the fatheads and suggests that effects were due to sediment contamination. Sediment metals such as arsenic and zinc and certain organic compounds, mainly some of the PAHs (Figure 4) were present in sediments at higher concentrations than at downstream locations. Sediment PCB concentrations were highest at this station. The higher levels of contaminants in these sediments, coupled with the low organic matter content, could result in a greater potential for release of contaminants from the sediments to the water. However, uptake experiments showed an increase in tissue concentrations only for some of the metals, while PCB concentrations in tissues remained below detection limits. High mortality was also observed in sediments from station 0011, but no corresponding mortality was noted among the fatheads at this station. While tissue residues were highest at station 0001 for both fatheads and mayflies, only a small increase was noted in mortality, despite a low concentration of sediment organic matter.

The bioaccumulation results (Tables 18, 19 and 20) show that for both the mayflies and the fathead minnows, only metals accumulated in organism tissues in the test sediments to concentrations higher than in the control sediments. Accumulation of metals in organism tissues was greatest from those sediments low in organic matter. Both copper and lead showed an increase in tissue residues over control sediments at station 0001 for both mayflies and fatheads. While sediment concentrations were not the highest at this station (Fig 2) release and uptake from station 0001 sediments appeared to be greatest. Tissue residues of all metals for both mayflies and fatheads kept in Rice Lake sediments, especially for mercury and cadmium, did not differ substantially from the controls. This may be a factor of binding of the metal to the sediments.

Chromium was accumulated by fatheads to concentrations higher than in control animals at station 0004. Sediment concentrations of chromium were low at this station, though the primarily sand substrate may not have been as effective in binding the metal to the sediment.

Tissue residues of PCBs were below detection limits for all organisms except the mayflies in sediments from station 0008 (Table 19). No corresponding tissue residues were noted in the fatheads and this single occurrence is difficult to attribute to any specific source, such as sediment contamination, especially since no apparent accumulation occurred at stations where sediment PCB concentrations were much higher (e.g. station 0004). Tissue residues of other organic compounds were generally below detection limits (Tables 19 and 20).

3.5 Benthic Invertebrates

Results of the benthic survey are presented in Tables 24 and 25. Station 15, located furthest upstream in the Trent Canal is considered as a control for purposes of comparison. Density and diversity of organisms at this station was low, with chironomids and oligochaetes comprising the entire fauna (Figure 9). The species present were, for the most part, those commonly considered typical of organically enriched areas, such as *Chironomus* and *Limnodrilus hoffmeisteri*. This, coupled with the absence of other species, indicates that a certain level of organic enrichment could be considered typical for the river as a whole.

Though substrates at station 0001 were composed primarily of sand, the fauna was more typical of depositional areas, yielding the highest density of organisms of any station both in the river and in Rice Lake. Oligochaetes (mainly *Limnodrilus hoffmeisteri*) comprised a much larger fraction of the fauna at this station than at any of the other stations in this survey (Fig 9) and are strongly suggestive of a relatively high level of organic enrichment. Though sediment metal concentrations were only moderately high, solvent extractable (oils, greases) concentrations and PAH concentrations were very high and these may have had an effect on species diversity as well, likely by eliminating the more sensitive organisms.

At station 0003, located in a depositional area characterized by a higher silt content (44% silt) and higher organic content *Chironomus* spp. made up the largest component of the benthos and, except for the predator *Procladius*, all species were fine sediment feeders. Noteworthy is the presence of the mayfly *Hexagenia limbata*. Bottom oxygen levels and flow characteristics are evidently sufficiently high to support this population despite the higher contaminant levels, especially the PCBs and the PAHs.

The low silt and organic content of the sediments at station 0004 suggest a moderate current prevailed in this section of the river. Most contaminant concentrations were low and reflected the low sorption properties of sandy substrates (Mudroch & Duncan 1986). The exception was the levels of PCBs which were the highest of the study area. Diversity of organisms was high (H' = 2.943), and much of the fauna was typical of organically enriched areas (*Limnodrilus* spp., *Chironomus* and *Cryptochironomus*). However, the presence of elmid beetles (*Dubiraphia* sp.) indicates an erosional substrate similar to station 0001. Given the differences in the substrate type between station 0003 and station 0004 it is difficult to attribute any differences in species composition to the effects of any single factor, such as the higher contaminant levels.

Station 0005 was located some distance downstream, also in an erosional area. The benthic fauna was typical of flowing water, but in this area also bore signs of organic enrichment. Chironomids and the oligochaete *Limnodrilus hoffmeisteri* formed the major part of the fauna though other species were present in moderately high densities. Most notable were the elmids (*Dubiraphia*) or riffle-beetles which formed the second largest group, as well as *H. limbata* and *Gammarus fasciatus*. Fine sediment feeders (all except *Phylocentropus* and *Palpomyia*, both predators) still comprised most of the fauna. Sediment contaminant concentrations were the lowest of any of the stations in the study area and this may have affected the species composition.

Station 0008 was located in Rice Lake at the mouth of the Otonabee River. The relatively high percentage of sand in this area, especially when compared to the rest of the lake, indicates that the river current is still a factor and that the main deposition of river suspended load occurs further away from the river mouth (turbidity and suspended particulates (Table 1) were highest here). Benthic diversity was high and compared well with most of the river stations, but in particular with station 0003 to which it was similar in substrate physical characteristics. Chironomids (*C. plumosus*) were the most common species, though density was low for other groups. Notable was the absence at this and all other stations in Rice Lake of the fine sediment feeding in-fauna typified by the oligochaetes. The low concentration of fine sediment and the higher level of coarse detritus that occurred throughout the lake is the most likely cause of the low density of these groups.

Both organic content and sediment contaminant concentrations were higher at station 0012 and indications are that this deeper area is acting as a settling basin, with resultant deposition of contaminated materials from the river. Benthic density was considerably lower than what has been observed in the river and was comprised of typical lake species such as *Chironomus plumosus* group. While the benthic community as a whole is

indicative of highly organic substrates, this does not necessarily imply polluted conditions and the low density of oligochaetes such as *Limnodrilus hoffmeisteri* is a strong indication the high organic levels were not due to organic pollution. Species composition indicates a high rate of decomposition of the organic matter with resultant lower oxygen levels since all of the species present are known to be able to survive in such conditions (Kennedy 1965; Frank 1983).

Located at the western end of Rice Lake, station 0006 was similar to station 0012 and differed only in the slightly lower contaminant levels. It would seem that circulation in the lake results in a somewhat greater deposition of contaminants closer to the mouth of the river, but that the overall circulation pattern in the western basin results in a nearly uniform distribution of materials in the sediments. The benthic community was also very similar to that at station 0012, consisting mainly of chironomids and a low population of oligochaetes.

Station 0009 was located east of the mouth of the Otonabee River in a large back-bay. Sediments were mainly sands, suggesting wave action or eddy flow from the river though with the exception of higher sediment PCB concentrations contaminant levels differed little from the western basin. The pattern of deposition suggests that most of the river flow diverts to the east with the remainder diverting west and circulating in the western end. Benthic density and diversity were higher as well (H' = 3.179, the highest recorded in the study area) and are likely due to greater current action which would have resulted in higher oxygen levels at the sediment interface. This, together with the coarse organic matter would have made this a more favourable environment for those benthic organisms less tolerant of low oxygen levels. This was particularly evident among the chironomids where a number of feeders on coarse materials such as *Endochironomus*, *Glyptotendipes* and *Dicrotendipes* appeared in addition to *Chironomus*, a species noted for its tolerance of low oxygen levels (Jonasson 1972).

Station 0014 was located east of the mouth of the Otonabee River in the deeper central section of the lake. The bulk sediment metal concentrations for lead, zinc, mercury and cadmium were the highest in Rice Lake, indicating that the deeper sections of the lake were also the areas of greatest deposition. Benthic density and diversity were both high and were similar to the other areas of the lake. Chironomids again dominated the fauna.

Bulk sediment contaminant concentrations were lower at stations 0007 and 0010 though the benthic community was little changed from the preceding stations. Density was reduced due mainly to the absence of *Chironomus* species which were common at the other stations in Rice Lake.

Station 0011 was located close to the outflow to the Trent River, at the eastern end of the lake in one of the deepest sections of the lake. Sediment contaminant concentrations were also slightly higher than at the preceding stations, though solvent extractables (mainly oils, greases) were highest of any of the stations. The benthic community consisted mainly of *Chironomus plumosus* group and this may be a factor of the slightly deeper depth of sampling. Decomposition of the organic matter which was present in profusion could, with greater depth, exert a greater oxygen stress. As sediment redox potentials indicate, anoxic conditions exist close to the sediment surface at all stations in Rice Lake and this effect could become more pronounced with depth. Of the fauna recorded from the lake, only *Chironomus* would be able to withstand very low sediment oxygen levels (Frank 1983).

Station 0013 was situated in the Trent River, 25 km downstream from Rice Lake. Sediments were still highly organic though contaminant levels were lower than in Rice Lake. *Chironomus* sp. dominated the benthic fauna and in fact few other species existed in this section. As at station 0011 the slightly greater depth may have been a factor.

In review, no specific effects of sediment contamination, including PCBs, could be determined on the benthic community. Both Beckett & Keyes (1983) and Winner *et al.* (1980) note that chemical contaminants, whether organics or metals, result in a reduction in density and diversity of the benthic community as a whole. These combined effects were absent in the Otonabee River, indicating the major factor affecting benthic organism distribution was organic matter enrichment of the sediments.

Rice Lake was generally a shallow, highly organic lake. Coarse detritus formed much of the substrate and this was the major determining factor for the benthic composition. Epibenthic forms, mainly chironomids but also amphipods (*Gammarus fasciatus*) and molluscs dominated while the sediment in-fauna, mainly oligochaetes, played only a minor role. Contaminant levels were moderately

high in Rice Lake and most were distributed throughout the lake,though these do not appear to have affected the benthic community. As noted, sediment type seems to be the major factor determining their composition.

4. DISCUSSION

The results of this study clearly show that the discharge of contaminants from a number of sources has affected the quality of the sediments in the vicinity of Peterborough through increased contaminant levels in the sediments and that this effect has persisted as far downstream as Rice Lake. The principal concerns are the increased sediment concentrations of PAHs and PCBs. The latter appear to originate from sources in Peterborough, while the origin of the PAHs needs to be determined.

The bottom water survey component indicates that while the sewage treatment plant has a minor effect on water quality, mainly evidenced as an increase in chloride, nitrate and ammonia concentrations, there are no other readily apparent water quality changes. Concentrations of contaminants were generally below detection limits.

Sediment metal concentrations were observed to increase in Peterborough independently of the organic matter content. Copper, lead and zinc were higher in sediment in Peterborough than at upstream locations and suggest that sources in Peterborough are contributing to the higher levels. However, sediment concentrations of copper, cadmium, mercury, lead and nickel exceeded the MOE Open-Water Disposal guidelines at the majority of stations both in the Otonabee River and in Rice Lake. The distribution suggests that background concentrations are rather high and sediment concentrations of these metals are difficult to attribute to any specific source other than general inputs (non-point sources) from the watershed.

Geochemical fractionation of the sediments indicates that certain metals, such as Cd, Cr, Cu, Pb and Zn were more closely associated with the less tightly bound fractions of sediment at and immediately downstream of Peterborough, and therefore are at least potentially more available to aquatic organisms. These same metals were found in the more resistant F4 and Residual fractions in the majority of stations in Rice Lake. If metals do in fact move into the more resistant fractions over time, as the work by Andrews (1988) suggests is the case for zinc, then the pattern of deposition indicates that the higher concentrations in the F1 to F3 fractions in the Otonabee River are due to recent deposition as compared to areas further downstream. The area of increased deposition in the F1 to F3 fractions appears to coincide with the potential sources in the Peterborough area, namely the STP and storm sewer outfalls.

It must be borne in mind that the geochemical fractionation of the sediments by the sequential extraction procedure merely measures the sediment bound metals in operationally defined extractable phases and these may not necessarily reflect the natural distribution of metals in sediments. Therefore, while the extraction procedure can be useful in providing an indication of the distribution of metals in various sediment phases, these are not necessarily indicative of the available concentrations of these metals to either the interstitial water or biota.

Significant accumulation of both PCBs and PAH compounds has occurred in the Otonabee River at Peterborough. Sediment levels of both exceeded draft Sediment Quality Guidelines at some stations that indicate adverse biological effects would be expected (Persaud *et al.* 1990). PCB concentrations in the sediment increased substantially at stations 0003 and 0004. A number of incidences of spills have occurred in the Peterborough area (Ferguson & Metcalfe 1989), some as recently as 1985. In addition, intermittent discharge of PCB contaminated materials have been suspected and a combination of these sources would account for the elevated concentrations both in the river and downstream into Rice Lake. PAH concentrations were very high in sediments at station 0001 and decreased rapidly downstream.

Tissue concentrations of contaminants in benthic invertebrates could not be related to levels in the water column or to bulk sediment concentrations. Tissue accumulation of metals occurred to higher than sediment concentrations at those stations (0004 and 0005) with the lowest organic matter content, suggesting that organic matter can serve to limit the availability of sediment bound contaminants. Tissue residues of some metals did correlate with levels in the geochemical fractions for Cd, Cr, Cu and Pb. The correlations do suggest that the availability of some metals may be limited by adsorption to certain sediment fractions.

Despite the high sediment concentrations of

PCBs, tissue residues in both benthic invertebrates and fish were low. No evidence of accumulation in tissues to levels higher than in sediments could be found. The similarity in tissue residues between the two types of organisms suggests that water and not sediment is the major source of uptake.

Uptake studies using clams (Hayton, Pers. Comm.) found that the greatest uptake occurred in the area of station 0001. In contrast, uptake was low in clams placed in the area of station 0004. The pattern of uptake of PCB by benthic invertebrates and bottom-dwelling fish in this study is similar to that of the clams and suggests that uptake is primarily from the water phase. The high sediment concentrations at station 0004 do not appear to be contributing directly to uptake by benthic organisms.

The analysis of fish tissues in relation to sediment contamination have proved to be difficult to interpret. Bottom feeding fish can accumulate contaminants from two different media. They can acquire contaminants from the water column through sorption onto external body surfaces, and they can also acquire contaminants through the ingestion of contaminated food items. It is at present difficult to differentiate the body burdens acquired from the sediment from the amount acquired from the water. Therefore, while fish provide an excellent means of assessing the biological availability of contaminants in a waterbody, they are unable to provide much insight into the availability of contaminants from specific sources such as the sediments. The use of sediment in-fauna appears to be a more appropriate means of assessing contaminant availability and uptake from sediment since these organisms are for the most part relatively sessile. Their virtually continuous exposure to sediment contaminants through ingestion of the solid phases as well as through surface adsorption from the interstitial water suggests that the contribution of contaminants from the dissolved phase in the water column would be minimal.

In general, tissue residues of metals were higher in benthic invertebrates than in the fish and suggest an increased availability from the sediments. The precise route of uptake, whether from sediment interstitial water or though ingestion of the solid phases, cannot be determined.

No significant increases in mortality were observed among either the mayflies or the fathead minnows, and the sediments cannot be considered as acutely toxic. However, an increase in mortality of both was observed at station 0004, suggesting some effects due to sediment contamination. Since the tests measured only acute mortality, it is possible that other, less pronounced effects may be present.

Some mortality was measured in sediments from stations 0008 and 0011, though in both cases the increase in mortality was noted in only one of the test organisms. The differences in the responses between the mayflies and the fathead minnows emphasize the importance of testing several aquatic organisms from different ecological niches. Due to habitat or metabolic differences in species, as well as differences in modes of release to the various aquatic compartments, bioavailability and/or uptake of contaminants can vary considerably between species.

Laboratory uptake studies showed little difference between field studies. The tissue levels of PCBs were generally low and indirectly points to the water column as the principal route of uptake, at least for the PCBs.

Benthic populations in the study area appear to respond mainly to the presence of organic matter. Though there was a reduction in diversity of the fauna at station 0004 as compared to station 0005, there is no direct indication that this could be due to the higher sediment contaminant concentrations of PCBs. While it is possible that high sediment concentrations of PCBs and PAHs may account for the high density of oligochaetes and the low diversity of other organisms at stations 0001 and 0003, the observed changes may simply be due to other, unmeasured factors. The benthic community in Rice Lake appeared to be primarily influenced by the type of organic matter. While sediment TOC was very high throughout the lake, visual inspection in the field indicated that this was primarily due to coarse organic matter.

As noted previously in this report, the presence of organic matter appears to mitigate the effects of contaminants in the sediments on aquatic organisms and may account for the higher density and diversity in organically enriched areas, despite the higher contaminant concentrations found in these sediments. No areas could be determined that clearly demonstrated effects of chemical contaminants on the benthic fauna. Responses on the community level are the sum product of both the natural environmental factors (i.e., substrate type, depth) and introduced factors (organic and inorganic contaminants, organic matter and physical

alterations) and it is extremely difficult to isolate the effects of changes in one phase (e.g. sediment contaminant concentrations) except where such changes have had a pronounced effect.

As is apparent from the results of this survey, the ability of such sampling programs to demonstrate direct cause-effect relationships between sediment contamination and biological effects is limited. In most cases effects of sediment contamination on aquatic biota can only be inferred from the data. In large measure, this is due to the lack of suitable mechanistic explanations for movement of these contaminants in the sediment as well as their action on biological systems.

The results of this study show that high levels of a number of contaminants do exist in the Otonabee River and that they are being transported downstream into Rice Lake. In some cases, the contaminants have found their way into the biota. Further work may be required to clearly delineating the sources of these contaminants (and their relative contributions) and the fate and pathways once they have been introduced into aquatic systems.

The present study has shown that while there is sediment contamination in the Otonabee River and Rice Lake from both PCBs and PAH, the biological effects from these are limited. While sediment concentrations of both were high, these have apparently not found their way into organism tissues. Rather, the study has suggested that the water column is the principal source of these contaminants to biota. The benthic component has demonstrated a depression of benthic diversity in those areas of higher sediment contaminant concentrations, though whether the effect is in response to the higher organic matter content of the sediments or to the contaminants that have also accumulated in these areas is difficult to determine. The presence of a toxic effect, at least on some components of the benthic community is confirmed by the increase in mortality in the test organisms in the laboratory study.

The strong potential for resuspension and transport of the contaminated sediments from the Otonabee River, and the continuing high sediment concentrations show that: 1) the sources of the material have not been controlled and 2) that the Otonabee River sediments are acting as a source for downstream contamination and possibly to the water column as well (in terms of resuspension of sediment). Both need to be controlled to prevent further contamination of the river-lake system.

5. CONCLUSIONS

1. Bottom water analyses showed no discernible concentrations of contaminants other than those associated with the Peterborough Sewage Treatment Plant discharge. Bottom water concentrations of PCBs were below detection limits.

2. Concentrations of metals in the sediments were high throughout the system. Concentrations of copper, lead and zinc at Peterborough were higher than at upstream locations. Concentrations were lower further downstream in the Otonabee River but increased again in Rice Lake. A number of sources are likely contributing to these elevated levels. Deposition of suspended material in Rice Lake from upstream sources is the major contributing factor to higher sediment contaminant concentrations in the lake.

3. Concentrations of PCBs in river sediments were very high at Peterborough and decreased further downstream. Concentrations were high in Rice Lake, suggesting that material from upstream is being deposited in the deeper parts of the lake. Concentrations in benthic organisms were generally low and did not reflect the distribution of PCBs in sediment. However, other studies, e.g., clams, have shown that higher uptake occurs in those areas of high sediment PCB concentration, though this does not necessarily imply that sediments are a direct source. Bottom sediments appear to act mainly as a sink for PCBs, though resuspension of sediment could serve to heighten their availability.

4. Sediment PAH concentrations were very high in Peterborough and decreased rapidly downstream. While sources can not be determined, an old coal gasification complex in Peterborough, as well as urban runoff, are among possible sources that would warrant investigation.

5. Tissue residues of contaminants in benthic invertebrates and fish were low for metals and generally below detection limits for organic compounds (PAHs were not analyzed) other than PCBs and indicate that most compounds were present in the sediment in unavailable forms. Little or no bioaccumulation could be attributed directly to sediment sources.

6. Sediment bioassays indicated that there was no acute toxicity from sediment associated contaminants, though mortality and uptake of some contaminants (mainly metals) was higher at certain stations.

7. Benthic community response suggests that the deposition of organic matter is the single most important factor affecting benthic invertebrate distribution. No clear impact of contaminants could be detected on the benthic community.

6. RECOMMENDATIONS

Contributions of contaminants such as PCBs and PAH from uncontrolled sources in Peterborough are the largest single contaminant concern in the Otonabeee River and Rice Lake system. Remedial action directed towards source control would therefore prevent further degradation. The need for additional remedial action should only be considered once source control has been fully implemented and its effectiveness assessed.

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Appendix 1

8. Figures

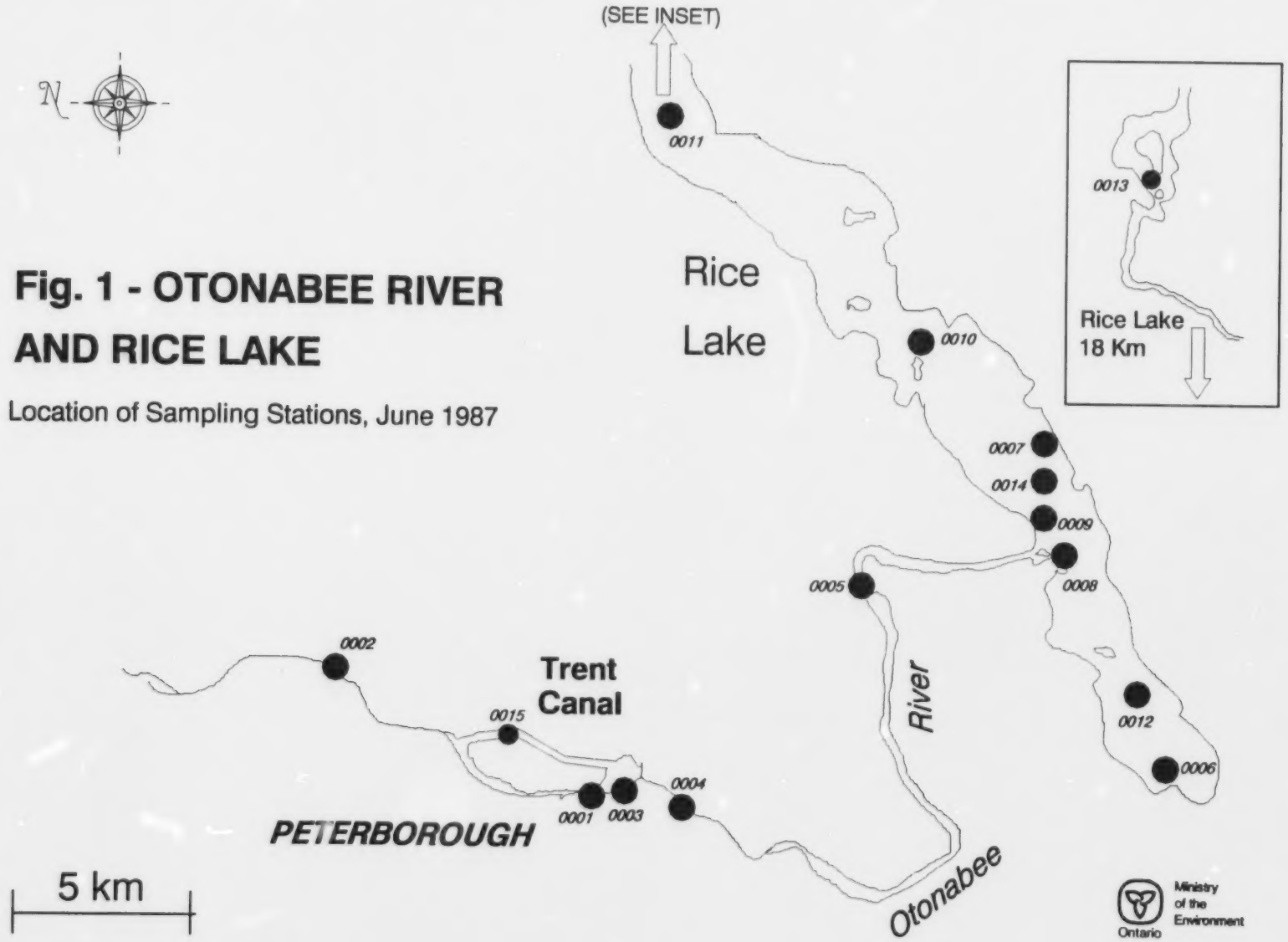


Fig. 1 - OTONABEE RIVER AND RICE LAKE

Location of Sampling Stations, June 1987

Fig. 1a.

OTONABEE RIVER

DETAIL OF

SAMPLING LOCATIONS

IN PETERBOROUGH,

1987.

Fig. 2a: Sediment Metal Concentrations

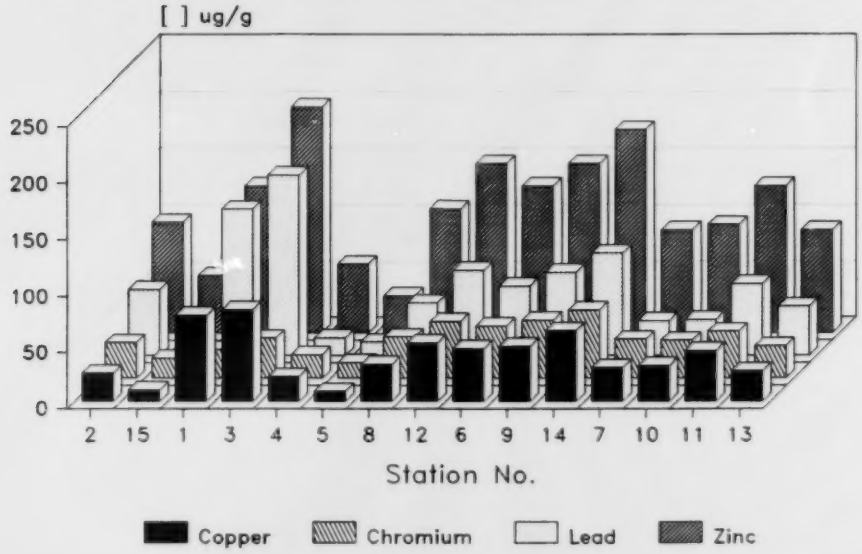
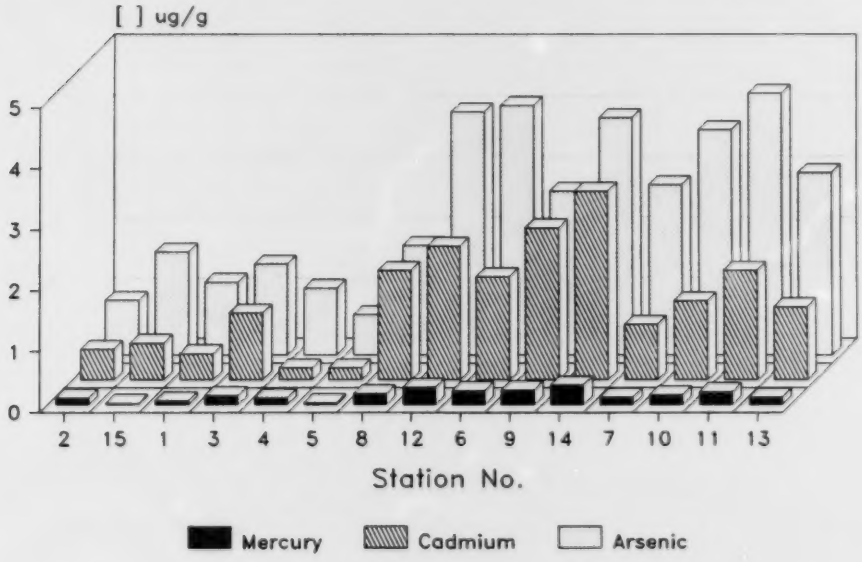


Fig. 2b: Sediment Metal Concentrations



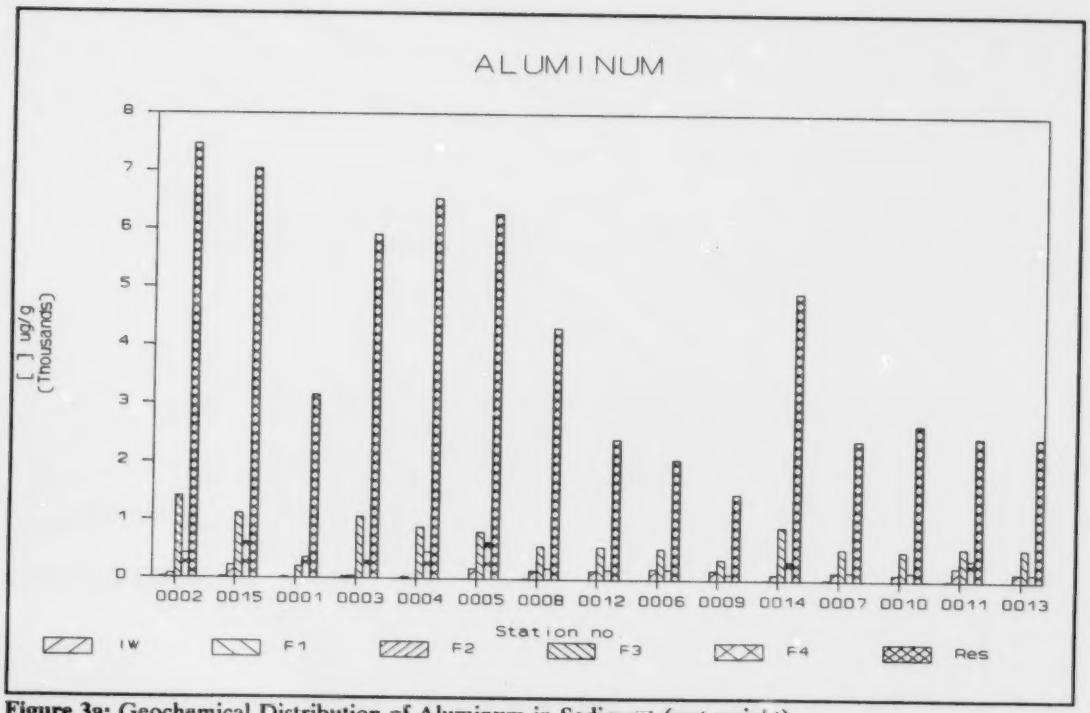


Figure 3a: Geochemical Distribution of Aluminum in Sediment (wet weight)

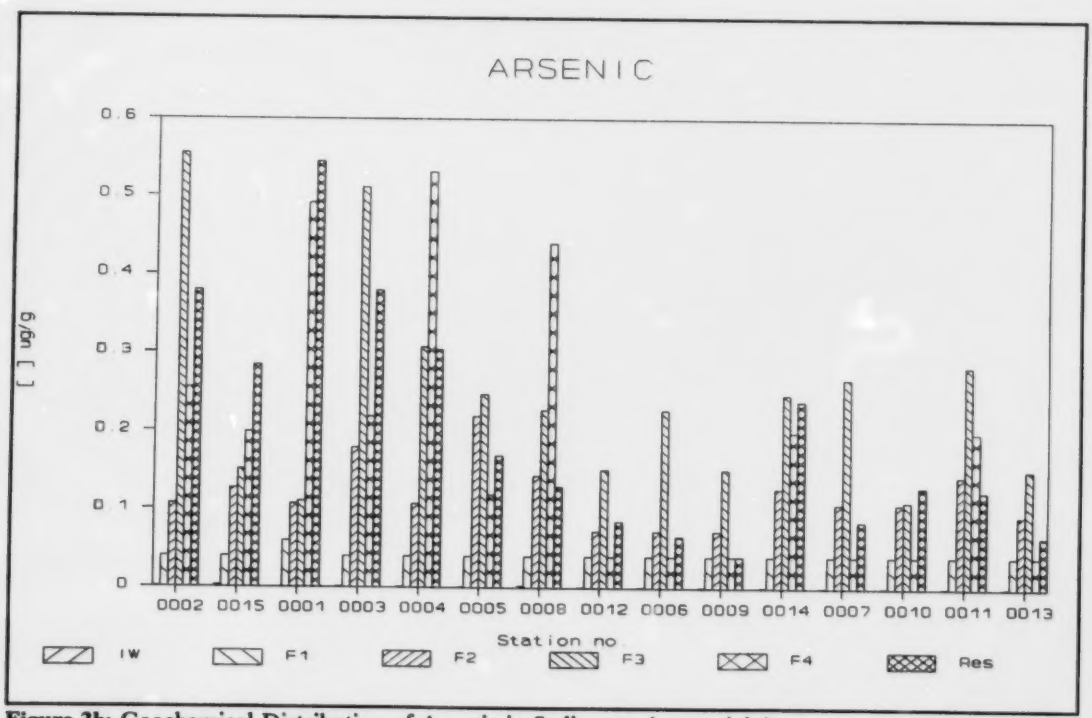


Figure 3b: Geochemical Distribution of Arsenic in Sediments (wet weight)

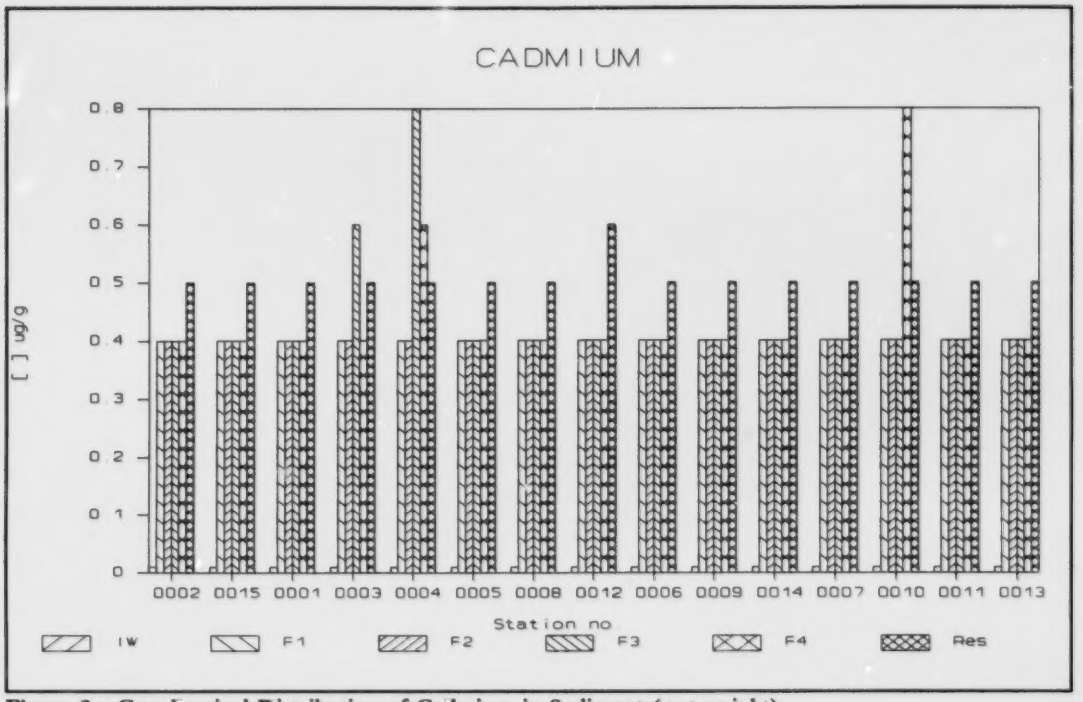


Figure 3c: Geochemical Distribution of Cadmium in Sediment (wet weight)

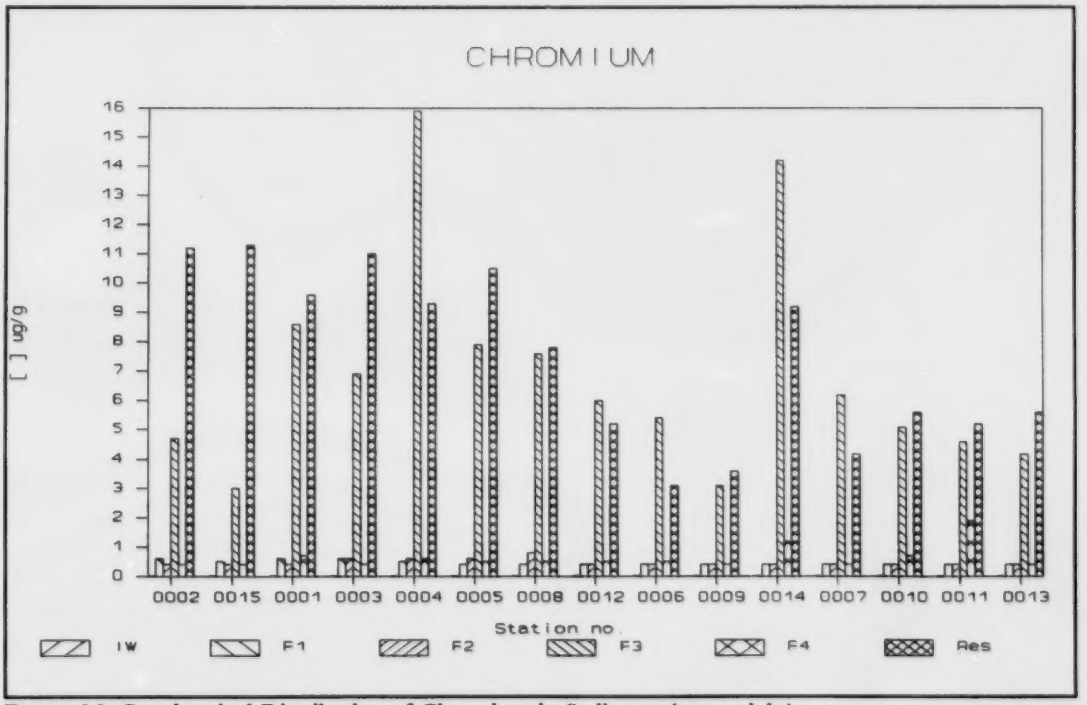


Figure 3d: Geochemical Distribution of Chromium in Sediment (wet weight)

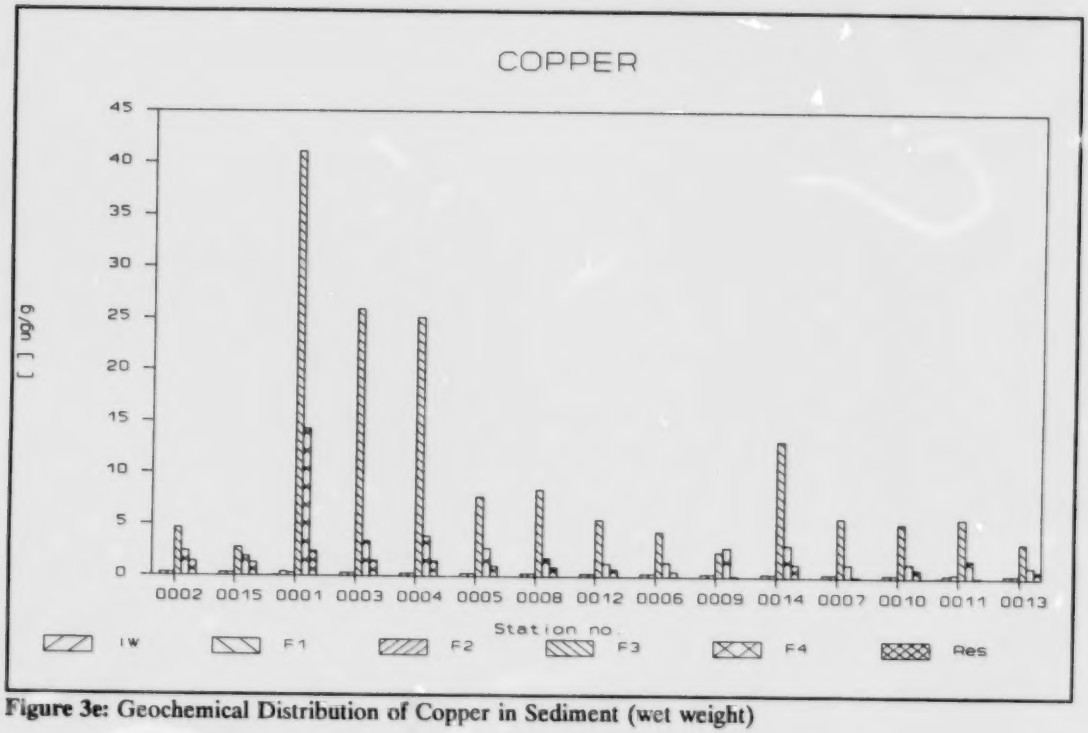


Figure 3e: Geochemical Distribution of Copper in Sediment (wet weight)

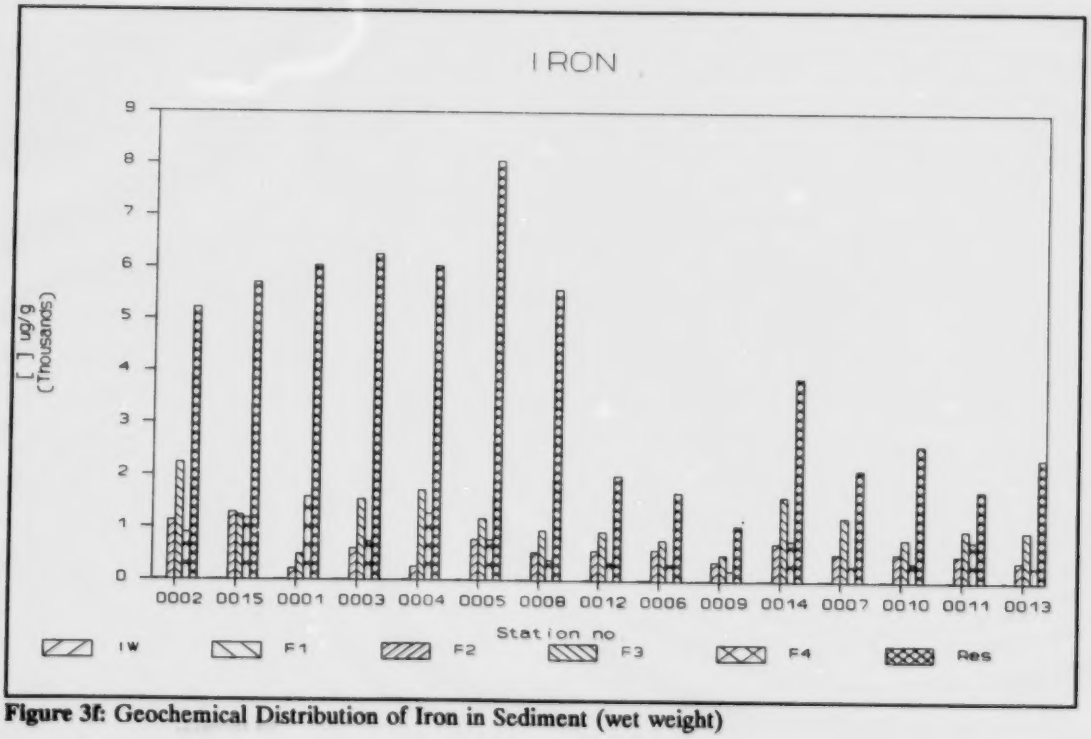


Figure 3f: Geochemical Distribution of Iron in Sediment (wet weight)

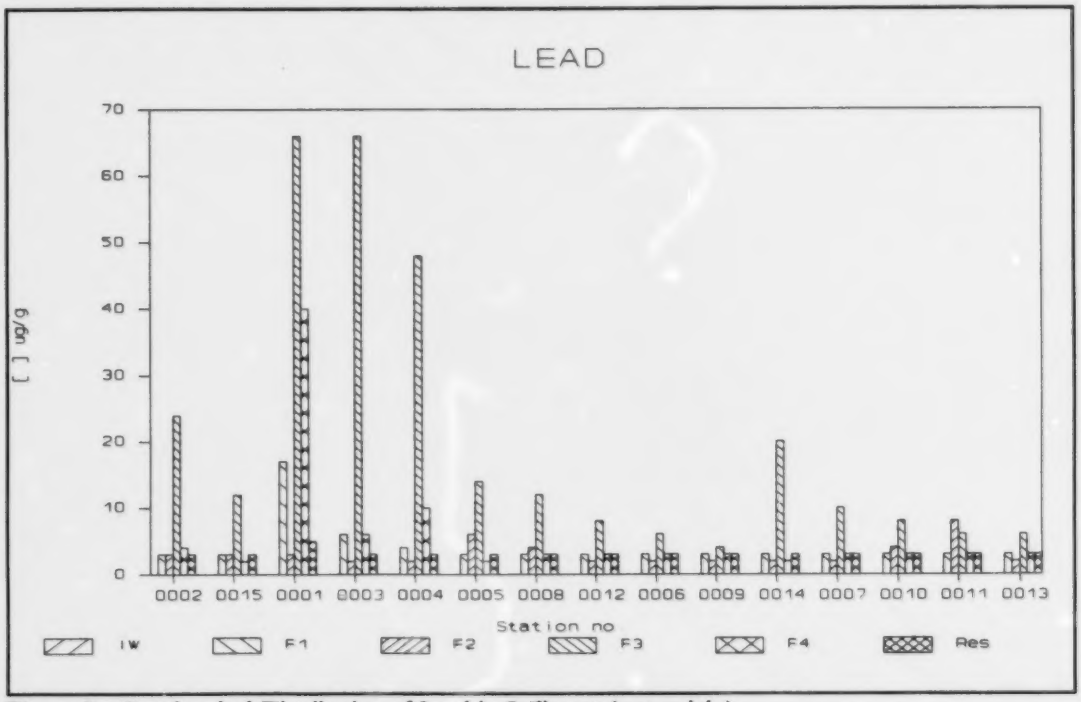


Figure 3g: Geochemical Distribution of Lead in Sediment (wet weight)

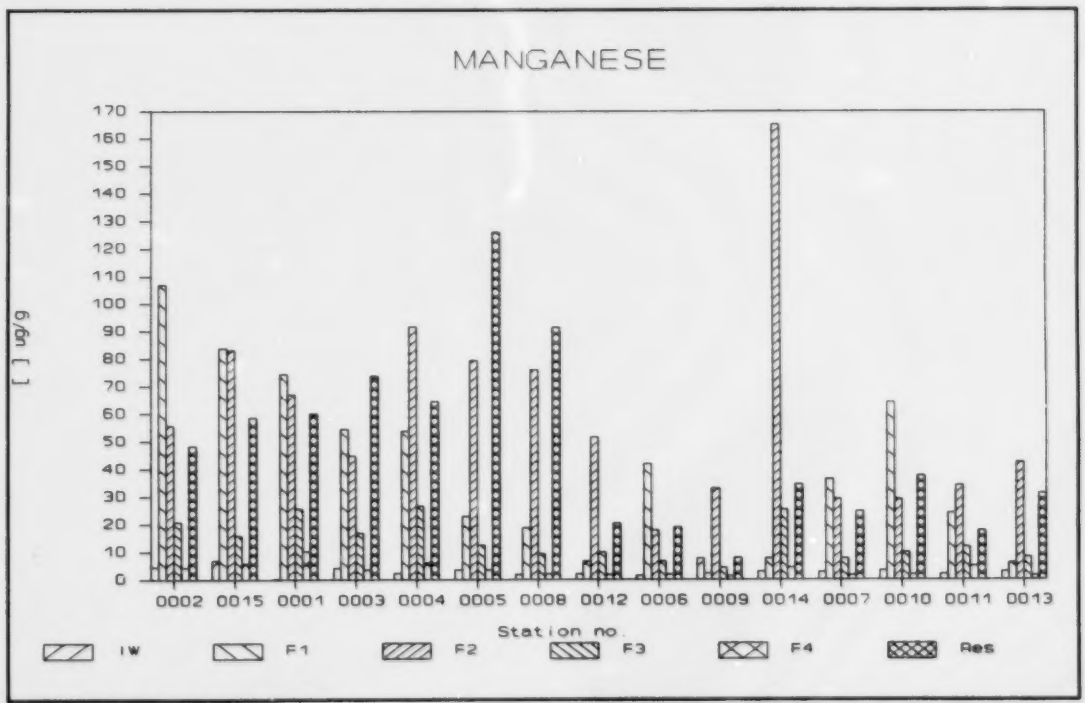


Figure 3h: Geochemical Distribution of Manganese in Sediment (wet weight)

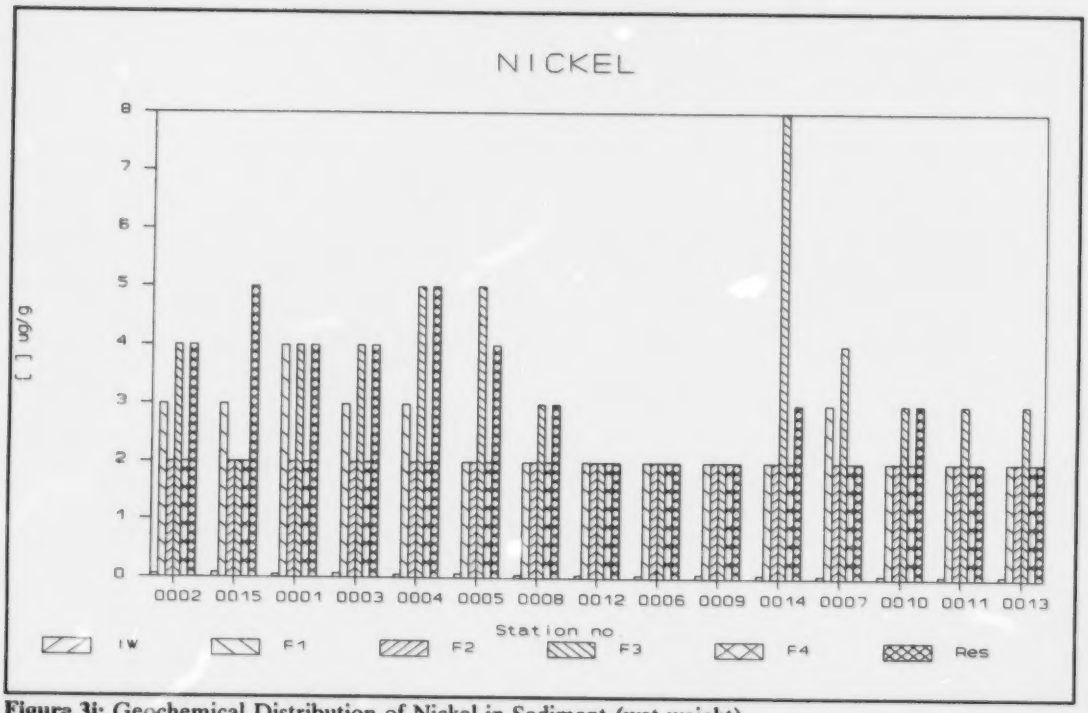


Figure 3i: Geochemical Distribution of Nickel in Sediment (wet weight)

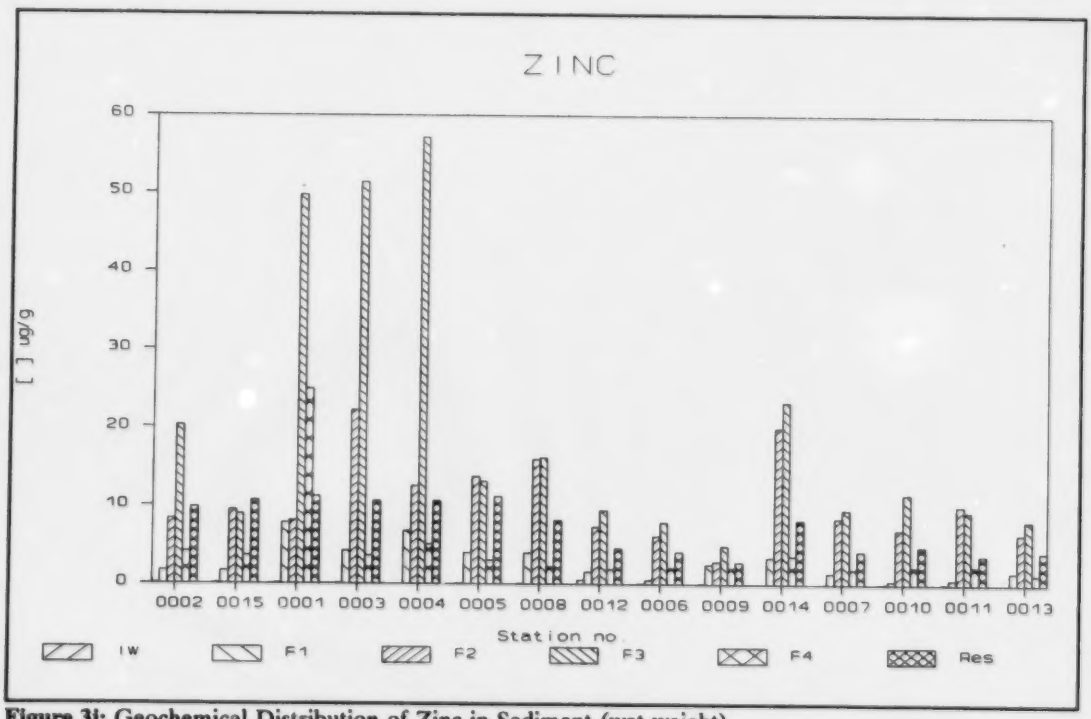


Figure 3j: Geochemical Distribution of Zinc in Sediment (wet weight)

Fig. 4a: Sediment PAH Concentrations

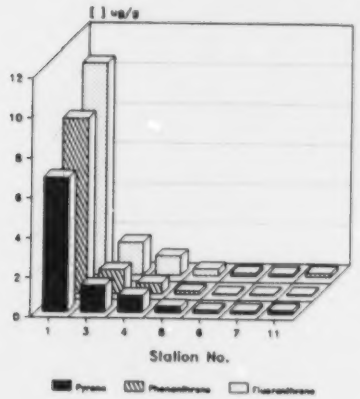


Fig. 4b: Sediment PAH Concentrations

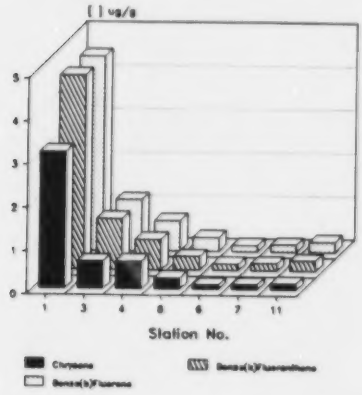


Fig. 4c: Sediment PAH Concentrations

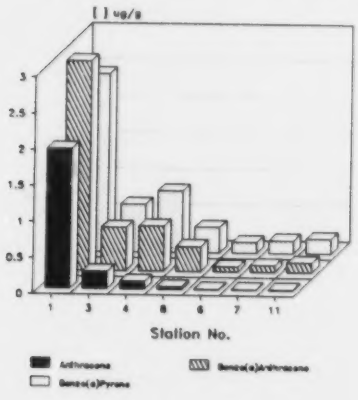


Fig. 4d: Sediment PAH Concentrations

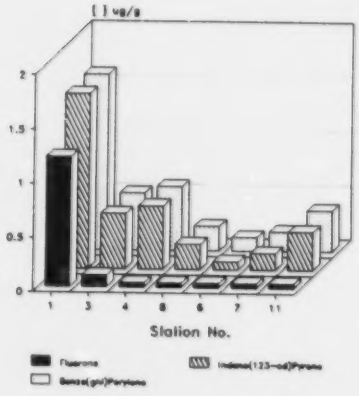


Fig. 4e: Sediment PAH Concentrations

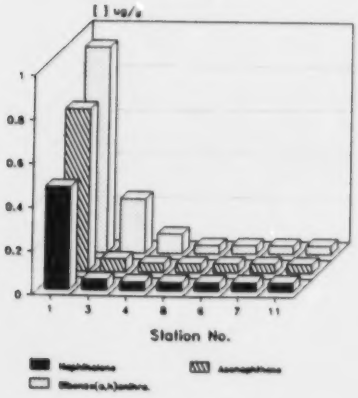


Fig. 4f: Total Sediment PAH Concentrations

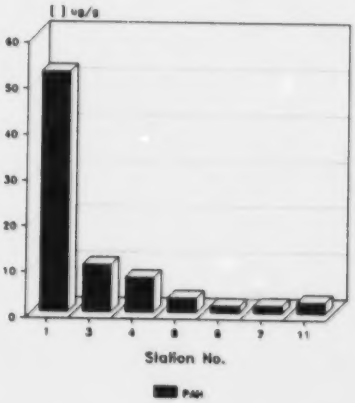


Fig. 5: Sediment PCB Concentrations

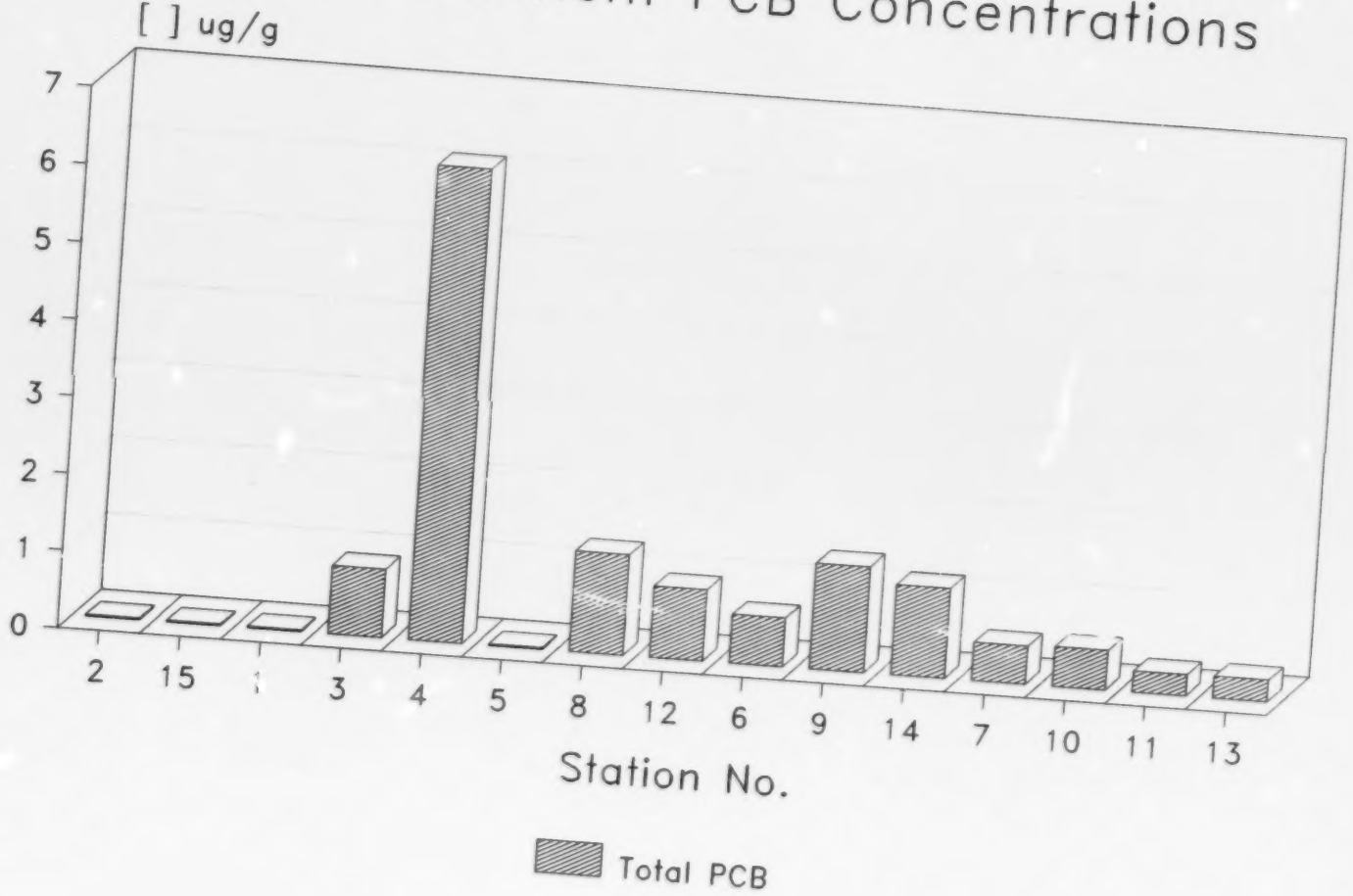


Fig 6a: Sediment–Biota Arsenic

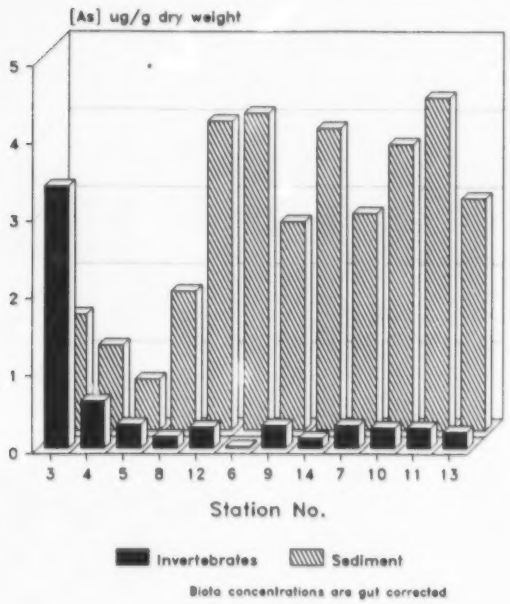


Fig 6b: Sediment–Biota Cadmium

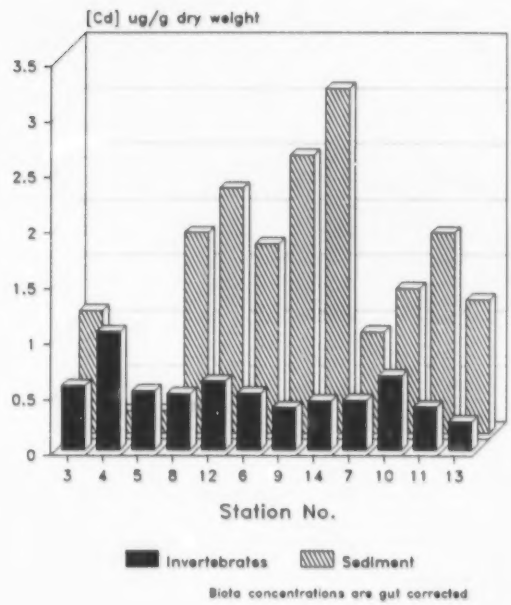


Fig 6c: Sediment–Biota Mercury

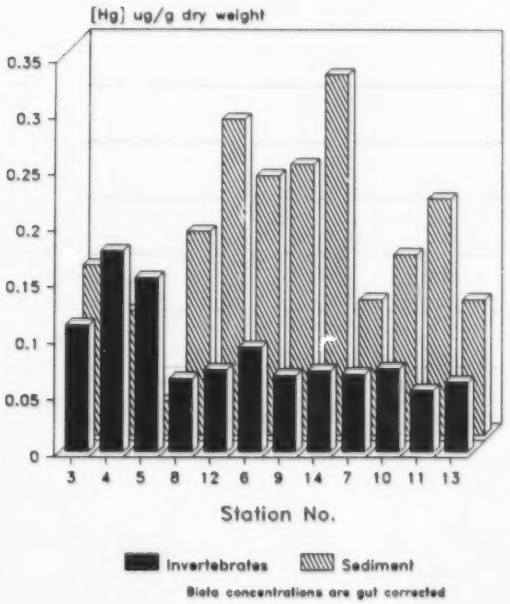


Fig 6d: Sediment–Biota Zinc

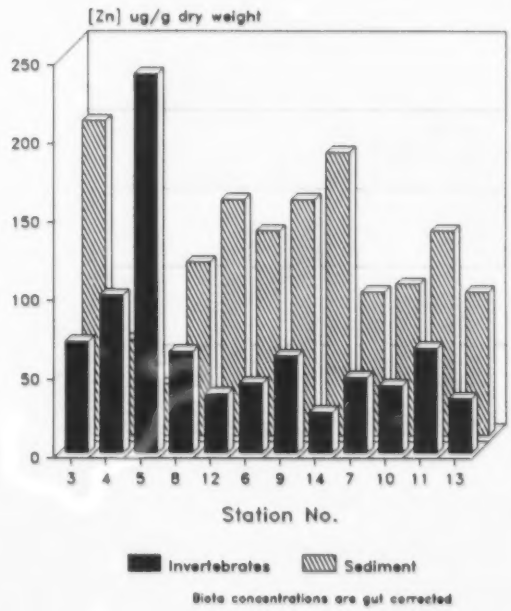


Fig 7a: Arsenic Tissue Residues

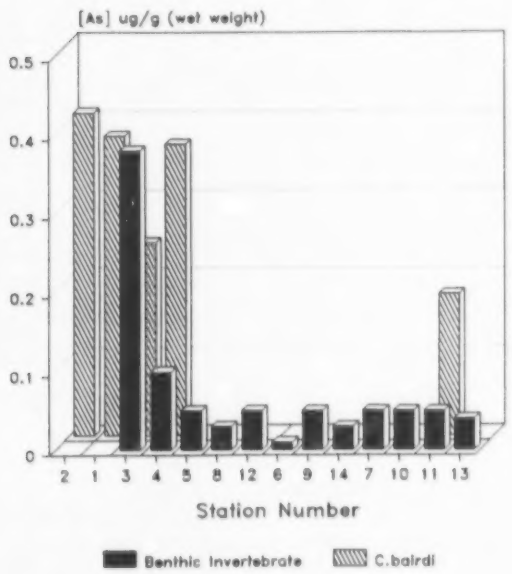


Fig. 7b: Cadmium Tissue Residues

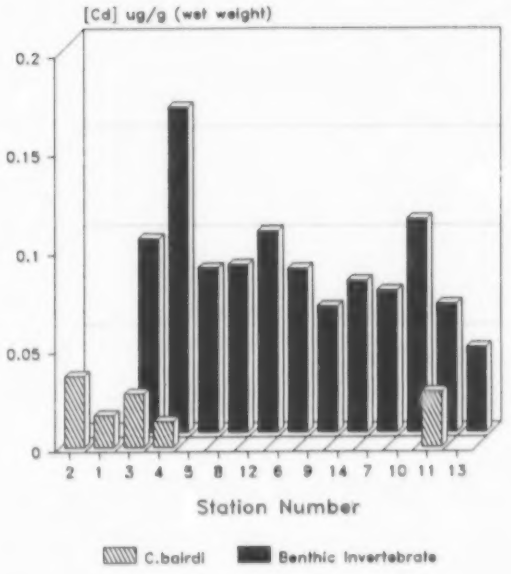


Fig. 7c: Chromium Tissue Residues

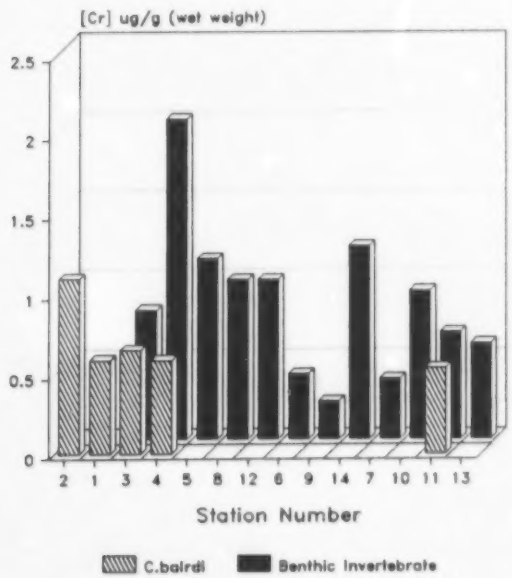


Fig. 7d: Copper Tissue Residues

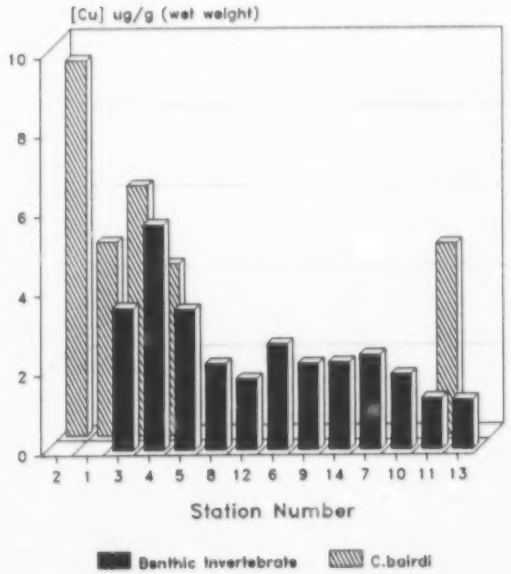


Fig. 7e: Lead Tissue Residues

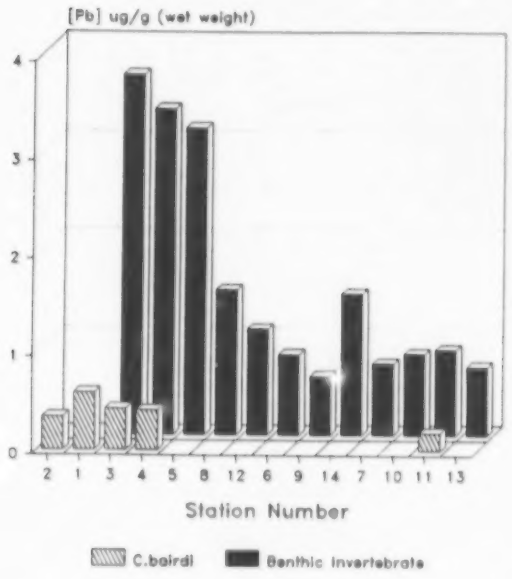


Fig. 7f: Mercury Tissue Residues

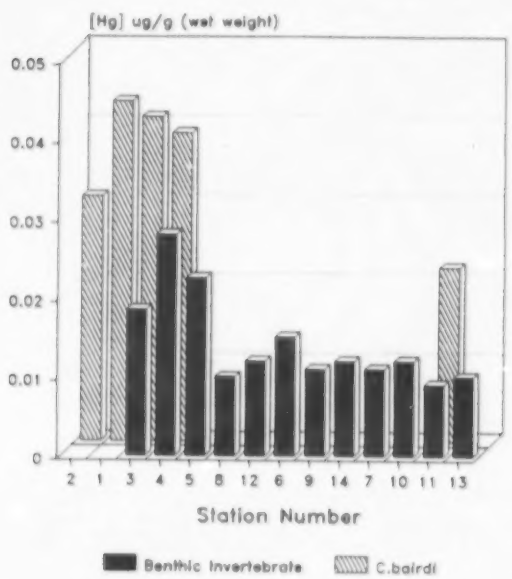


Fig. 7g: Zinc Tissue Residues

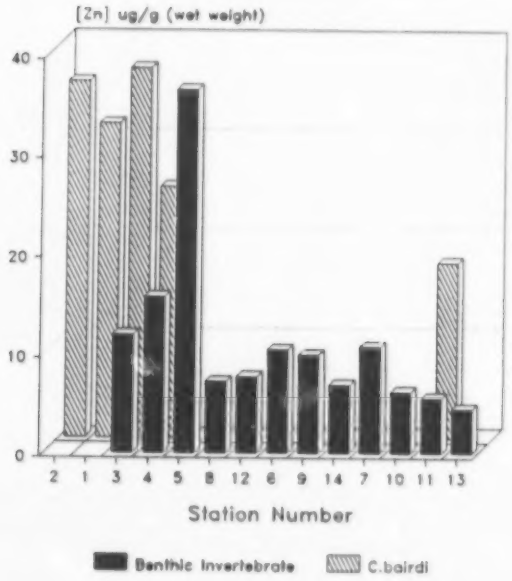


Fig. 7h: PCB Tissue Residues

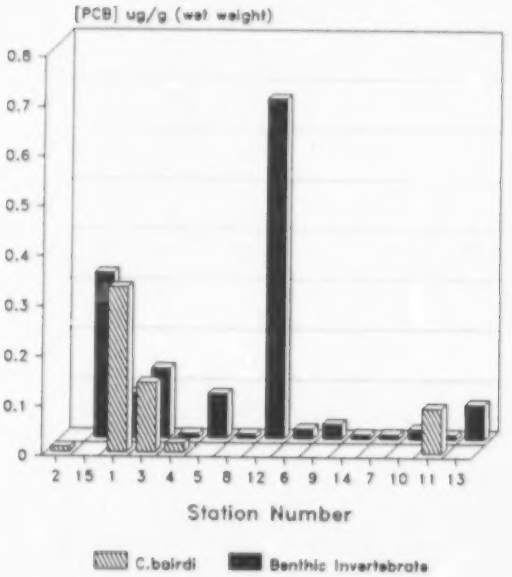


Fig 8a: Sediment Bioassay Tissue Residues – Cadmium

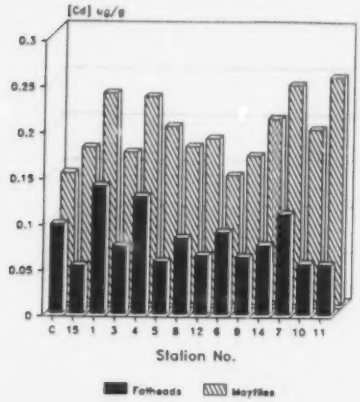


Fig. 8b: Sediment Bioassay Tissue Residues – Chromium

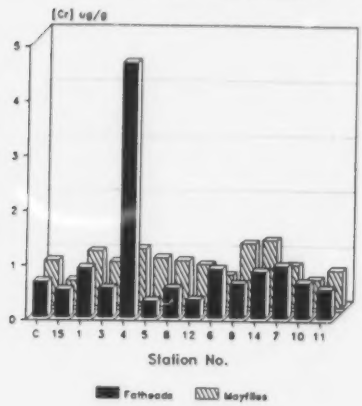


Fig. 8c: Sediment Bioassay Tissue Residues – Copper

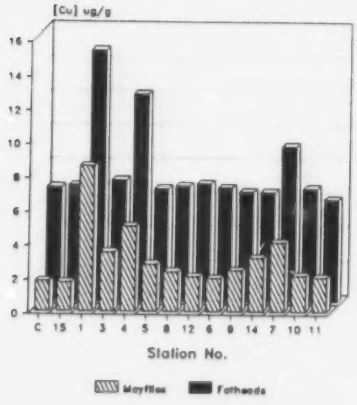


Fig. 8d: Sediment Bioassay Tissue Residues – Lead

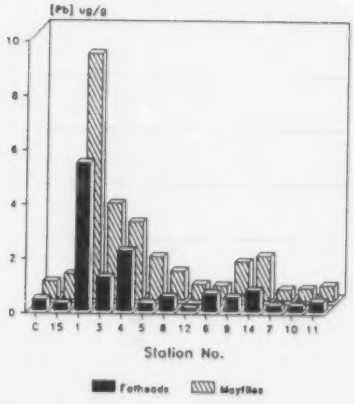


Fig. 8e: Sediment Bioassay Tissue Residues – Mercury

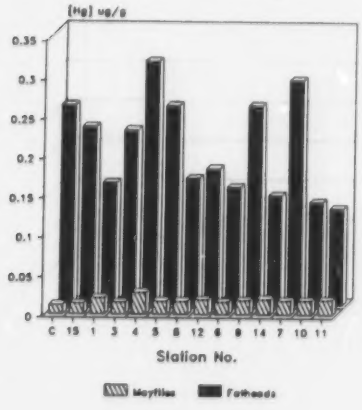


Fig. 8f: Sediment Bioassay Tissue Residues – Zinc

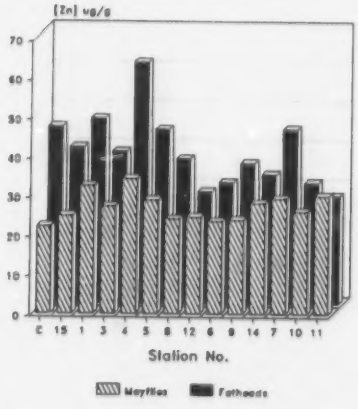
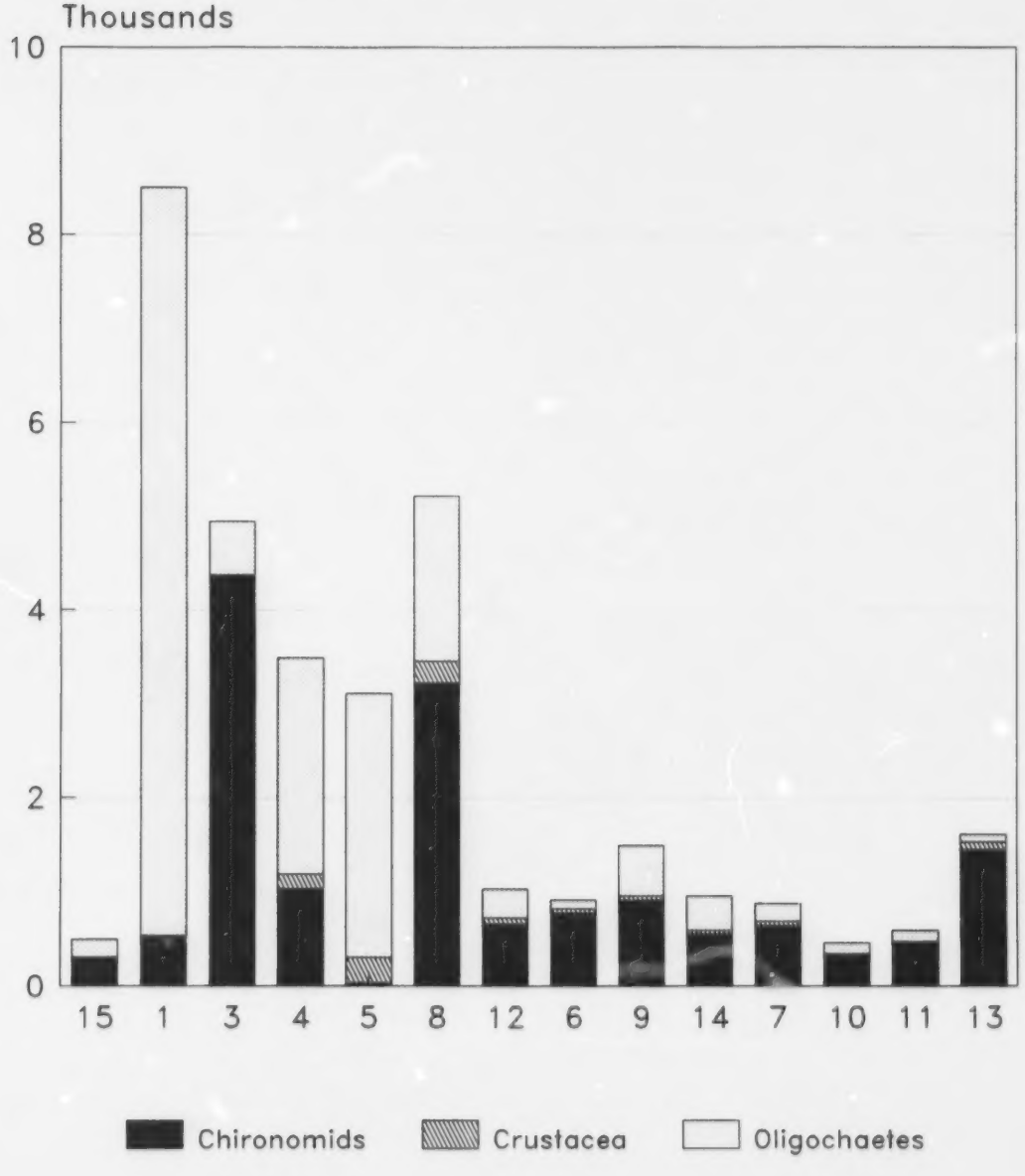


Fig 9: Distribution of Major Benthic Invertebrate Groups



Appendix 2

9. Tables

Table 1: In-Place Pollutants Program
WATER - Nutrients, Metals, DH, Ions (to off bottom)
Rice Lake - Otonabee R. 1987
UNITS: As Stated

Station #	Depth m	Conductivity @ 25 c	Hardness	Sodium	Potassium	Alkalinity	pH	Acidity Total	Fluoride	Chloride	Sulphate	Residue Filtrate	Residu Partic	Turbidity	Colour True	Phosphorus	Nitr'n Total	Ammonium Total Frac. Reac.	Nitrates Total Frac. Reac.	Nitrite Frac. Reac.	Phenolics	Chemical Oxygen Demand	Dissolved Organic Carbon	Dissolved Inorganic Carbon
		CO umho/cm	HA mg/l	NA mg/l	K mg/l	ALKg/l	pH	AC mg/l	FI mg/l	Cl mg/l	S mg/l	RSP mg/l	RSP mg	TURB	COL TRE	P mg/l	TKN mg/l	AM mg/l	NAOTFR mg/l	NAOZFR mg/l	PHNOL ug/l	COD mg/l	DOC mg/l	DIC mg/l
0002	2.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0015	4.5	219.0	106.0	4.1	1.16	95.8	8.19	2.06 <T	0.05	7.2	6.6	142.0	15.7	3.8	16.5	0.026	0.51	0.104 <T	0.030	0.0055	-	16.0	5.1	21.6
0001	2.1	234.0	111.0	4.7	1.16	101.7	8.30	0.78	0.10	8.3	7.6	17.0	7.0	2.3*	16.0	0.014	0.35	0.064 <T	0.070	0.0055	-	13.5	4.8	22.6
0003	5.0-6.0	227.0	109.0	4.8	1.17	99.9	8.29	1.18	0.07	7.3	7.3	140.0	5.1	1.6	15.0	0.016	0.37	0.068 <T	0.065	0.0100	-	12.4	4.8	22.6
0004	1.2-1.6	240.0	115.0	6.3	1.37	103.7	8.26	1.69	0.11	10.4	8.9	161.0	4.1	2.2	15.0	0.058	0.60	0.508	0.165	0.0465	-	13.9	5.0	23.4
0005	1.0-1.2	250.0	117.0	5.8	1.32	107.7	8.21	2.13	0.10	9.2	8.8	163.0	5.5	3.4	12.0	0.033	0.52	0.174	0.155	0.0140	-	12.5	4.9	24.2
0006	2.5	250.0	118.0	5.6	1.27	107.8	8.16	2.95	0.09	9.4	9.2	163.0	16.4	8.5	14.0	0.056	0.61	0.222 <T	0.080	0.0085	-	18.5	5.2	24.4
0012	5.0-6.0	210.0	99.0	5.4	1.43	90.1	8.23	1.34	0.07	9.3	8.0	142.0	10.4	4.2	12.0	0.031	0.49	0.050 <T	0.020 <T	0.0030	-	16.6	4.9	19.8
0008	6.0	211.0	95.5	5.5	1.33	86.3	8.19	1.35	0.06	9.1	7.9	137.0	7.7	4.9	11.5	0.031	0.55	0.066 <T	0.030	0.0060	-	17.0	4.9	19.2
0009	3.0	240.0	110.0	5.6	1.27	106.0	8.23	0.53	0.09	9.3	9.1	160.0	12.9	6.4	14.0	0.051	0.61	0.116 <T	0.075	0.0050	-	17.8	5.1	24.0
0014	4.0	234.0	108.0	5.6	1.32	99.1	8.25	1.60	0.08	9.3	8.9	152.0	12.4	5.2	13.0	0.055	0.62	0.092 <T	0.085	0.0320	-	18.5	5.8	21.4
0007	3.0	219.0	100.0	5.5	1.43	90.3	8.20	1.66	0.07	9.3	8.8	142.0	23.2	6.6	14.0	0.053	0.68	0.078 <T	0.045	0.0060	-	22.2	5.0	20.4
0010	4.0	229.0	104.0	5.8	1.46	95.8	8.29	1.02	0.09	9.5	8.6	149.0	10.4	5.7	12.0	0.031	0.48	0.060	0.020 <T	0.0030	-	19.3	5.0	21.6
0011	7.0	215.0	97.5	5.3	1.19	89.4	8.26	1.66	0.08	9.2	8.6	140.0	5.6	2.5	13.0	0.022	0.69	0.200 <T	0.030 <T	0.0040	-	17.4	5.1	20.0
0013	6.0	232.0	107.0	5.3	1.07	95.6	7.79	0.97	0.11	8.5	9.0	151.0	10.7	2.9	15.0	0.023	0.67	0.232	0.030	0.0050	-	15.4	4.8	21.0

KEY: < LOWER THAN DETECTION LIMIT
<T THIS LOW MEASUREMENT IS TENTATIVE - FOR INFORMATION ONLY
- NO DATA

> RESULT GREATER THAN REPORTED VALUE
CR CALCULATED RESULT

Table 2: In-Place Pollutants Program

WATER - Metals

Rice Lake - Otonabee R. 1987

Units: As Stated

Station #	Depth	Field		Copper	Chromium	Mercury	Cadmium	Iron	Lead	Zinc	Arsenic	Manganese	Aluminum	Nickel	Calcium
	M	Ph	EH	Cu mg/l	Cr mg/l	Hg ug/l	Cd mg/l	Fe mg/l	Pb mg/l	Zn mg/l	As mg/l	Mn mg/l	Al mg/l	Ni mg/l	CA mg/l
0002	2.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0015	4.5	7.90	-	<0.001	<0.001*	0.01	< 0.0003	0.200	0.004	0.009	<0.001	0.069	0.120	<0.002	32.000
0001	2.1	8.08	-	0.001	<0.001*	0.02	< 0.0003	0.190	0.003	0.021	<0.001	0.030	0.057	<0.002	35.000
0003	5.0-6.0	8.05	-	0.001	<0.001*	0.04	< 0.0003	0.073	0.005	0.002	<0.001	0.037	0.046	<0.002	33.000
0004	1.2-1.6	8.00	-	0.001	<0.001*	0.02	< 0.0003	0.065	0.006	0.004	<0.001	0.028	0.047	<0.002	34.000
0005	1.0-1.2	7.85	-	0.001	<0.001*	0.02	< 0.0003	0.110	0.004	0.004	<0.001	0.034	0.087	<0.002	35.000
0008	2.5	8.00	-	0.001	<0.001*	0.02	< 0.0003	0.240	0.006	0.003	<0.001	0.092	0.190	<0.002	36.000
0012	5.5-6.0	8.08	-	<0.001	<0.001*	0.02	< 0.0003	0.180	0.004	0.002	<0.001	0.065	0.056	<0.002	28.000
0006	6.0	7.93	-	<0.001	<0.001*	0.02	< 0.0003	0.160	0.003	0.003	<0.001	0.075	0.068	<0.002	27.000
0009	3.0	8.05	-	0.001	<0.001*	0.02	< 0.0003	0.180	0.004	0.004	<0.001	0.072	0.120	<0.002	35.000
0014	4.0	8.02	-	<0.001	<0.001*	0.03	< 0.0003	0.190 <	0.003	0.002	<0.001	0.082	0.094	0.007	32.000
0007	3.0	8.06	-	0.004	<0.001*	0.02	< 0.0003	0.320	0.005	0.004	<0.001	0.076	0.200	<0.002	30.000
0010	4.0	8.05	-	0.001	<0.001*	0.02	< 0.0003	0.120	0.003	0.003	<0.001	0.053	0.082	<0.002	31.000
0011	7.0	8.05	-	0.001	<0.001*	0.02	< 0.0003	0.091	0.005	0.005	<0.001	0.054	0.053	<0.002	29.000
0013	6.0	-	-	0.001	<0.001*	0.06	< 0.0003	0.240 <	0.003	0.039	<0.001	0.170	0.059	<0.002	39.000

KEY: < LOWER THAN DETECTION LIMIT

- NO DATA

* APPROXIMATE RESULT

Table 3: In-Place Pollutants Program

WATER - PCBs and Pesticides (1m off bottom)

Rice Lake - Otonabee R 1987

UNITS: ng/l

Station #	Depth m	Aldrin	A-BHC Hexa-chloro cyclo hexane	B-BHC Hexa-chloro cyclo hexane	G-BHC Hexa-chloro cyclo hexane	A chlor-dane	G chlor-dane	Dieldrin	DMDT Meth-oxychlor	Endo-sulfan I	Octa Chloro-Styrene	Endo-sulfan II	Endrin	Endo-sulfan sulfate	Hepta-chlor-epoxide	Hepta-chlor	Mirex	Oxy-chloro-dane	OP-DDT	PCB total	PP-DDD	PP-DDE	PP-DDT	Hexa-chloro-benzene
0002	2 3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0015	4 5	<1	< 1	<1	<1	<2	<2	<2	<5	<2	<1	<4	<4	<4	<1	<1	<5	<2	<5	<20	<5	<1	<5	<1
0001	2 1	<1	< 1	<1	<1	<2	<2	<2	<5	<2	<1	<4	<4	<4	<1	<1	<5	<2	<5	<20	<5	<1	<5	<1
0003	5 0-6 0	<1	< 1	<1	<1	<2	<2	<3	<5	<2	<1	<4	<4	<4	<1	<1	<5	<2	<5	<20	<5	<1	<5	<1
0004	1 2-1 6	<1	<11	<1	<12	<2	<2	<2	<5	<2	<1	<4	<4	<4	<1	<1	<5	<2	<5	<20	<5	<1	<5	<1
0005	1 0-1 2	<1	< 1	<1	<1	<2	<2	<2	<5	<2	<1	<4	<4	<4	<1	<1	<5	<2	<5	<20	<5	<1	<5	<1
0008	3 5	<1	< 1	<1	<1	<2	<2	<2	<5	<2	<1	<4	<4	<4	<1	<1	<5	<2	<5	<20	<5	<1	<5	<1
0012	5 5-6 0	<1	< 1	<1	<1	<2	<2	<2	<5	<2	<1	<4	<4	<4	<1	<1	<5	<2	<5	<20	<5	<1	<5	<1
0006	6 0	<1	< 1	<1	<1	<2	<2	<2	<5	<2	<1	<4	<4	<4	<1	<1	<5	<2	<5	<20	<5	<1	<5	<1
0009	3 0	<1	< 1	<1	<1	<2	<2	<2	<5	<2	<1	<4	<4	<4	<1	<1	<5	<2	<5	<20	<5	<1	<5	<1
0014	4 0	<1	< 1	<1	<1	<2	<2	<2	<5	<2	<1	<4	<4	<4	<1	<1	<5	<2	<5	<20	<5	<1	<5	<1
0007	3 0	<1	< 1	<1	<1	<2	<2	<2	<5	<2	<1	<4	<4	<4	<1	<1	<5	<2	<5	<20	<5	<1	<5	<1
0010	4 0	<1	< 1	<1	<1	<2	<2	<2	<5	<2	<1	<4	<4	<4	<1	<1	<5	<2	<5	<20	<5	<1	<5	<1
0011	7 0	<1	<12	<1	<1	<2	<2	<2	<5	<2	<1	<4	<4	<4	<1	<1	<5	<2	<5	<20	<5	<1	<5	<1
0013	6 0	<1	< 1	<1	<1	<2	<2	<2	<5	<2	<1	<4	<4	<4	<1	<1	<5	<2	<5	<20	<5	<1	<5	<1

Table 6 In-Place Pollutants Program

WATER - Organics (in off bottom)

Rice Lake - Otonabee R. 1987

UNITS ng/L

Station #	Depth m	Hexa-chloro ethane	1,3,5 Trichloro benzene	1,2,4 Trichloro benzene	Hexa Chloro-butadiene	1,2,3 Trichloro benzene	2,4,5 Trichloro toluene	2,3,6 Trichloro toluene	1,2,3,5 Tetrachloro benzene	1,2,4,5 Tetrochloro benzene	2,6,8 Trichloro toluene	Tetra-chloro-benzene	Penta-chloro-benzene	Tosa-Phene	Dicamba	2,4-Dl Propionic Acid	2,4-Dl chlorophenoxy Acetic Acid	2,4,5-Trl chlorophenoxy Acetic Acid	2,4-Dl chlorophenoxy Buty Ric Acid	Silvex	Picloram
0002	2.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0015	4.5	<1	<5	<5	<1	<5	<5	<5	<1	<1	<5	<1	<1	-	-	-	-	-	-	-	-
0001	2.1	<1	<5	<5	<1	<5	<5	<5	<1	<1	<5	<1	<1	-	-	-	-	-	-	-	-
0003	5.0-6.0	<1!	<5	<5	<1	<5	<5	<5	<1	<1	<5	<1	<1	-	<50	<100	<100	<50	<200	<20	-
0004	1.2-1.6	<1	<5	<5	<1	<5	<5	<5	<1	<1	<5	<1	<1	-	<50	<100	<100	<50	<200	<20	-
0008	1.0-1.2	<1	<5	<5	<1	<5	<5	<5	<1	<1	<5	<1	<1	-	<50	<100	<100	<50	<200	<20	-
0006	2.5	<1	<5	<5	<1	<5	<5	<5	<1	<1	<5	<1	<1	-	-	-	-	-	-	-	-
0012	5.5-6.0	<1	<5	<5	<1	<5	<5	<5	<1	<1	<5	<1	<1	-	<50	<100	<100	<50	<200	<20	-
0006	6.0	<1	<5	<5	<1	<5	<5	<5	<1	<1	<5	<1	<1	-	-	-	-	-	-	-	-
0009	3.0	<1	<5	<5	<1	<5	<5	<5	<1	<1	<5	<1	<1	-	<50	<100	<100	<50	<200	<20	-
0014	4.0	<1	<5	<5	<1	<5	<5	<5	<1	<1	<5	<1	<1	-	-	-	-	-	-	-	-
0007	3.0	<1	<5	<5	<1	<5	<5	<5	<1	<1	<5	<1	<1	-	-	-	-	-	-	-	-
0010	4.0	<1	<5	<5	<1	<5	<5	<5	<1	<1	<5	<1	<1	-	<50	<100	<100	<50	<200	<20	-
0011	7.0	<1	<5	<5	<1	<5	<5	<5	<1	<1	<5	<1	<1	-	-	-	-	-	-	-	-
0013	6.0	<1	<5	<5	<1	<5	<5	<5	<1	<1	<5	<1	<1	-	<50	<100	<100	<50	<200	<20	-

KEY: < LOWER THAN DETECTION LIMIT

<! THIS LOW MEASUREMENT IS TENTATIVE - FOR INFORMATION ONLY

- NO DATA

able 5: In-Place Pollutants Program
SEDIMENT - Particle Size
Rice Lake - Otonabee R. 1987
UNITS: uM

Station #	Gravel >1000	Sand 1000-44	Silt 42.21-3.73	Clay 3.73-0.17
0002	< 0.1 ()	36.0	58.7	8.7
0015	0.8	56.5	33.7	6.0
0001	0.7	84.7	11.1	1.7
0003	0.2	47.4	44.0	5.5
0004	0.6	87.0	9.2	1.4
0005	< 0.1	81.2	11.1	1.8
0008	0.2	57.3	33.5	3.5
0012	-	-	-	-
0006	-	-	-	-
0009	0.2	48.2	41.8	4.4
0014	-	-	-	-
0007	-	-	-	-
0010	-	-	-	-
0011	-	-	-	-
0013	-	-	-	-

KEY: < LOWER THAN DETECTION LIMIT
- NO DATA
() ESTIMATED RESULT

Table 6: In-Place Pollutants Program
SEDIMENT - metals
Rice Lake - Otonabee R. 1987
UNITS: As Stated (dry weight)

Station #	Field		Loss on Ignition	Phosphorous	Total Kjeldahl Nitrogen	Total Organic Carbon	Copper	Chromium	Mercury	Cadmium	Iron	Lead	Zinc	Arsenic	Manganese	Aluminum	Nickel	Solvent Extractables
	Ph	Eh	LOI %	TP ug/g	TKN ug/g	TOC ug/g	Cu ug/g	Cr ug/g	Hg ug/g	Cd ug/g	Fe ug/g	Pb ug/g	Zn ug/g	As ug/g	Mn ug/g	Al ug/g	Ni ug/g	Sol. Ext. ug/g
0002	6.91 -	160 *	19.0 *	1.20 *	7.2 *	90.0 *	25.0 *	33.0	0.11	0.50 *	21000 *	59.0	98.0	0.90	570.0	1700	14.0 *	4170
0015	7.13 -	175 *	7.0	0.80 *	2.4 *	32.0	10.0	10.0	0.02	0.60 *	15000	25.0	51.0	1.70	360.0	7400	6.3	1300
0001	7.08 -	220 *	7.0 *	1.00	1.6 *	36.0 *	77.0 *	20.0	0.06	0.43 *	12000 *	130.0 *	130.0	1.20	240.0	4300	7.4 *	15200
0003	7.06 -	130 *	16.0 *	1.30 *	4.4 *	77.0 *	82.0 *	36.0	0.15 *	1.10 *	19000 *	160.0 *	200.0	1.50	490.0	1200	14.0 *	6860
0004	7.17 -0	145	3.5 *	1.00	1.1 *	19.0	22.0	21.0	0.11 <	0.20 *	10000	16.0	61.0	1.10	200.0	4000	8.9 *	1900
0005	7.22 -0	189 EV	2.9 *	1.00	1.1 *EV	180.0	8.9	14.0	0.03 <	0.20	6500	12.0	33.0	0.56	190.0	4200	7.1	940
0008	7.30 -	60 *	16.0 *	1.30 *	5.4 *	69.0 *	33.0 *	37.0	0.18 *	1.80 *	14000	47.0 *	110.0	1.80	440.0	7400	18.0 *	2340
0012	7.05 -	165 *EV	35.0 *	1.30 *	14.6 *	170.0 *	52.0 *	51.0	0.26 *	2.20 *	25000 *	76.0 *	150.0	4.00	620.0	16000	28.0 *	9340
0006	7.11 -	188 *EV	36.0 *	1.60 *	18.3 *	170.0 *	47.0 *	47.0 EV	0.23 *	1.70 *	22000 *	62.0 *	130.0	4.10	560.0	15000	26.0 *	6400
0009	7.06 -	122 *	18.0 *	1.30 *	8.0 *	83.0 *	49.0 *	52.0	0.24 *	2.50 *	17000 *	74.0 *	150.0	2.70	470.0	12000	23.0 *	4600
0014	7.37 -	188 *EV	23.0 *	1.40 *	8.7 *EV	110.0 *	63.0 *	61.0 *	0.32 *	3.10 *	24000 *	91.0 *	180.0	3.90	710.0	15000	27.0 *	5770
0007	6.84 -	190 *EV	34.0 *	1.00 *	13.1 *	160.0 *	38.0 *	35.0	0.12	0.91 *	17000	31.0	91.0	2.80	260.0	13000	19.0 *	3070
0010	7.04 -	110 *AV	2.0 *	1.10 *	13.1 *	88.0 *	32.0 *	34.0	0.16 *	1.30 *	19000	32.0	96.0	3.70	300.0	12000	20.0 *	7000
0011	7.05 -0	177 *EV	37.0 *	1.40 *	16.8 *	130.0 *	45.0 *	42.0	0.21 *	1.60 *	22000 *	84.0 *	130.0	4.30	500.0	16000	27.0 *	19100
0013	7.06 -	177 *EV	30.0 *	1.00 *	16.1 *	160.0 *	37.0 *	29.0	0.12 *	1.20 *	18000	44.0	91.0	3.00	440.0	11000	19.0 *	7410

KEY: < LOWER THAN DETECTION LIMIT
<T THIS LOW MEASUREMENT IS TENTATIVE - FOR INFORMATION ONLY
- NO DATA
* EQUALS OR EXCEEDS MOE GUIDELINES FOR OPEN WATER DISPOSAL OF DREDGED MATERIAL
AV RESULT IS THE RESULT OF <2 ANALYSES

Table 7: In-Place Pollutants Program
Sediment - Geochemical Distribution of metals
Diss Lake - November 8, 1987
Units: ug/g dry weight

ALUMINUM

STATION	HW	F1	F2	F3	F4	RES	MAX	SUM	F3 + F4	SUM F1-F4
0010	< 0.01	30.7	230.0	1110	940	7040	9140	9099	1710	1909
0001	0.90	33.7	< 0.1	302	380	3160	3240	3736	982	976
0002	< 0.01	22.7	96.3	1410	430	7460	9220	9305	1836	1935
0003	< 0.01	35.2	30.0	1060	293	3910	7600	7337	1353	1417
0004	< 0.01	28.1	3.6	884	462	6540	7980	7915	1346	1373
0005	< 0.01	5.0	170.0	967	634	6370	6690	7994	1641	1634
0006	< 0.01	16.7	153.0	973	187	4310	4980	5236	760	930
0012	< 0.01	4.9	142.0	884	172	3610	3910	3293	726	883
0006	0.98	4.3	187.0	536	177	2870	3680	2974	713	904
0009	< 0.01	3.9	173.0	351	183	1480	6140	2100	483	630
0014	< 0.01	6.0	99.0	917	330	4930	6930	6304	1247	1354
0007	< 0.01	16.3	137.0	339	152	3480	4110	3344	691	844
0010	0.83	4.3	113.0	505	133	3600	3350	3494	638	774
0011	0.00	7.1	230.0	964	367	3470	3680	3640	931	1176
0013	< 0.01	8.0	130.0	994	140	3460	4830	3290	934	830

KEY: < Less than detection limit
- No data

ARSENIC

STATION	HW	F1	F2	F3	F4	RES	MAX	SUM	F3 + F4	SUM F1-F4
0010	0.002	< 0.040	0.127	0.151	0.199	0.384	0.839	0.761	0.350	0.817
0001	-	0.060	0.107	0.111	0.491	0.944	1.310	1.253	0.602	0.769
0002	< 0.001	< 0.040	0.107	0.385	0.255	0.379	0.864	1.290	0.610	0.957
0003	< 0.001	< 0.040	0.179	0.311	0.319	0.379	1.300	1.290	0.730	0.949
0004	< 0.001	< 0.040	0.107	0.307	0.931	0.384	1.290	1.269	0.838	0.965
0005	< 0.001	< 0.040	0.319	0.347	0.119	0.169	0.599	0.734	0.366	0.635
0006	0.003	< 0.040	0.163	0.337	0.440	0.139	0.439	0.939	0.667	0.898
0012	< 0.001	< 0.040	0.073	0.181	< 0.040	0.083	0.949	0.348	0.191	0.303
0006	< 0.001	< 0.040	0.073	0.337	< 0.040	0.083	0.940	0.484	0.367	0.370
0009	< 0.001	< 0.040	0.073	0.191	< 0.040	< 0.040	0.704	0.383	0.191	0.383
0014	< 0.001	< 0.040	0.127	0.347	0.199	0.239	0.975	0.812	0.446	0.613
0007	< 0.001	< 0.040	0.107	0.367	< 0.040	0.083	0.704	0.499	0.387	0.454
0010	< 0.001	< 0.040	0.107	0.111	< 0.040	0.139	0.499	0.367	0.151	0.298
0011	< 0.001	< 0.040	0.163	0.303	0.199	0.134	0.574	0.749	0.483	0.665
0013	< 0.001	< 0.040	0.062	0.151	< 0.040	0.065	0.655	0.340	0.191	0.333

KEY: < Less than detection limit
- No data

CADMIUM

STATION	HW	F1	F2	F3	F4	RES	MAX	SUM	F3 + F4	SUM F1-F4
0010	< 0.01	< 0.4	< 0.4	< 0.4	< 0.4	< 0.5	< 0.5	0.0	0.0	1.6
0001	< 0.01	< 0.4	< 0.4	< 0.4	< 0.4	< 0.5	< 0.5	0.0	0.0	1.6
0002	< 0.01	< 0.4	< 0.4	< 0.4	< 0.4	< 0.5	< 0.5	0.0	0.0	1.6
0003	< 0.01	< 0.4	< 0.4	0.5	< 0.4	< 0.5	0.6	0.6	1.0	1.6
0004	< 0.01	< 0.4	< 0.4	0.5	0.5	< 0.5	< 0.5	1.4	1.4	3.2
0005	< 0.01	< 0.4	< 0.4	< 0.4	< 0.4	< 0.5	< 0.5	0.0	0.0	1.6
0006	< 0.01	< 0.4	< 0.4	< 0.4	< 0.4	< 0.5	< 0.5	0.0	0.0	1.6
0012	< 0.01	< 0.4	< 0.4	< 0.4	< 0.4	0.5	< 0.5	0.6	0.6	1.6
0006	< 0.01	< 0.4	< 0.4	< 0.4	< 0.4	< 0.5	< 0.5	0.0	0.0	1.6
0009	< 0.01	< 0.4	< 0.4	< 0.4	< 0.4	< 0.5	< 0.5	0.0	0.0	1.6
0014	< 0.01	< 0.4	< 0.4	< 0.4	< 0.4	< 0.5	< 0.5	0.0	0.0	1.6
0007	< 0.01	< 0.4	< 0.4	< 0.4	< 0.4	< 0.5	0.9	0.0	0.0	1.6
0010	< 0.01	< 0.4	< 0.4	< 0.4	0.5	< 0.5	0.7	0.0	1.2	2.0
0011	< 0.01	< 0.4	< 0.4	< 0.4	< 0.4	< 0.5	< 0.5	0.0	0.0	1.6
0013	< 0.01	< 0.4	< 0.4	< 0.4	< 0.4	< 0.5	< 0.5	0.0	0.0	1.6

KEY: < Less than detection limit

CHROMIUM

STATION	HW	F1	F2	F3	F4	RES	MAX	SUM	F3 + F4	SUM F1-F4
0010	< 0.01	0.5	< 0.4	3.0	< 0.4	11.3	11.7	10.2	3.4	4.2
0001	< 0.01	0.6	< 0.4	6.6	0.7	9.6	10.0	10.5	9.3	10.3
0002	< 0.01	0.6	< 0.4	4.7	< 0.4	11.3	11.9	10.3	5.1	6.1
0003	< 0.01	0.6	0.5	5.9	< 0.4	11.0	10.1	10.1	7.3	8.5
0004	< 0.01	0.5	0.6	10.9	0.6	9.3	20.5	36.9	10.5	17.6
0005	< 0.01	< 0.4	0.5	7.9	0.5	10.5	10.2	10.5	8.4	9.4
0006	< 0.01	< 0.4	0.5	7.6	0.5	7.8	14.0	10.7	8.1	9.3
0012	< 0.01	< 0.4	< 0.4	6.0	0.3	5.2	10.0	11.7	6.3	7.3
0006	< 0.01	< 0.4	< 0.4	5.4	0.5	3.1	12.1	9.0	5.9	6.7
0009	< 0.01	< 0.4	< 0.4	3.1	< 0.4	3.6	10.1	8.7	3.5	4.3
0014	< 0.01	< 0.4	< 0.4	14.2	1.2	9.3	23.3	34.6	15.4	16.2
0007	< 0.01	< 0.4	< 0.4	0.2	< 0.4	4.2	10.7	10.0	6.6	7.4
0010	< 0.01	< 0.4	< 0.4	5.1	0.7	5.6	7.5	11.4	5.8	6.6
0011	< 0.01	< 0.4	< 0.4	4.6	1.9	5.2	9.1	12.1	6.5	7.3
0013	< 0.01	< 0.4	< 0.4	4.2	< 0.4	5.0	13.5	10.2	4.6	5.4

KEY: < Less than detection limit

COPPER

STATION	HW	F1	F2	F3	F4	RES	MAX	SUM	F3 + F4	SUM F1-F4
0010	< 0.000	< 0.3	< 0.3	2.7	1.9	1.3	3.8	3.9	4.6	5.2
0001	0.000	0.6	< 0.3	41.1	14.3	2.4	63.5	58.3	55.6	56.1
0002	< 0.000	< 0.3	< 0.3	6.6	3.4	1.6	7.1	6.4	7.8	7.6
0003	0.014	< 0.3	< 0.3	25.9	3.4	1.5	36.9	30.8	29.3	29.9
0004	< 0.000	< 0.3	< 0.3	23.1	3.9	1.5	46.3	30.5	29.0	29.6
0005	< 0.000	< 0.3	< 0.3	7.7	2.7	1.8	10.6	11.6	10.4	11.0
0006	< 0.000	< 0.3	< 0.3	8.6	1.6	0.9	9.6	11.1	10.2	10.8
0012	0.011	< 0.3	< 0.3	5.8	1.3	0.7	7.8	7.8	6.8	7.6
0006	< 0.000	< 0.3	< 0.3	4.3	1.6	0.8	6.6	6.3	5.7	6.3
0009	< 0.000	< 0.3	< 0.3	2.6	2.0	< 0.1	10.1	5.3	5.2	5.8
0014	< 0.000	< 0.3	< 0.3	13.2	3.1	1.3	20.7	17.6	16.3	16.9
0007	< 0.000	< 0.3	< 0.3	5.7	1.3	< 0.1	9.6	7.8	7.8	7.6
0010	< 0.000	< 0.3	< 0.3	5.2	1.6	0.8	10.6	7.6	6.8	7.2
0011	0.039	< 0.3	0.6	5.7	1.8	< 0.1	7.7	7.9	7.5	8.2
0013	< 0.000	< 0.3	< 0.3	3.6	1.1	0.7	7.1	5.2	4.8	5.1

KEY: < Less than detection limit

IRON

STATION	HW	F1	F2	F3	F4	RES	MAX	SUM	F3 + F4	SUM F1-F4
0010	6.64	7.0	1360	1230	1170	5700	10300	9387	2400	3637
0001	3.42	11.4	208	499	1500	6830	6940	8310	2089	2356
0002	7.62	4.9	1130	2230	982	5310	8660	9477	3132	4267
0003	4.14	5.6	664	1530	726	6390	9200	9110	2256	3066
0004	1.00	4.1	393	1710	1270	6830	10000	9367	2980	3337
0005	2.09	4.0	768	1170	770	6850	9470	10771	1940	3721
0006	3.13	3.0	530	944	391	9370	9200	7430	1335	1906
0012	0.30	4.5	969	931	343	3000	4630	3843	1274	1843
0006	3.69	4.7	906	770	322	1660	4230	3372	1101	1093
0009	4.32	4.6	361	496	300	1050	8330	2114	800	1004
0014	4.76	3.0	731	1010	770	3890	9630	9904	2380	3104
0007	2.75	4.0	518	1230	796	2130	5320	6160	1816	2639
0010	5.00	9.0	530	805	363	3400	3420	4300	1168	1708
0011	1.45	4.3	496	985	776	1740	4310	4005	1763	2363
0013	4.20	2.4	382	960	381	2360	3410	3903	1361	1835

KEY: < Less than detection limit

LEAD

STATION	I0	F1	F2	F3	F4	SED	MAX	SUB	F3 + F4 SUB F1-F4
0000	< 0.00	< 3.0	< 3.0	12	< 3.0	< 3.0	18	14.0	14.0	20.0
0001	< 0.00	17.0	< 3.0	66	40.0	9.0	134	130.0	106.0	126.0
0002	< 0.00	< 3.0	< 3.0	34	4.0	< 3.0	30	26.0	38.0	34.0
0003	< 0.00	6.0	< 3.0	66	6.0	< 3.0	90	83.0	72.0	80.0
0004	< 0.00	4.0	< 3.0	46	10.0	< 3.0	55	64.0	56.0	64.0
0005	< 0.00	< 3.0	6.0	14	< 3.0	< 3.0	18	22.0	16.0	22.0
0006	< 0.00	< 3.0	4.0	12	< 3.0	< 3.0	13	16.0	16.0	22.0
0012	< 0.00	< 3.0	< 3.0	8	< 3.0	< 3.0	13	10.0	11.0	16.0
0005	< 0.00	< 3.0	< 3.0	6	< 3.0	< 3.0	7	8.0	9.0	14.0
0009	< 0.00	< 3.0	< 3.0	4	< 3.0	< 3.0	25	6.0	7.0	13.0
0014	< 0.00	< 3.0	< 3.0	20	< 3.0	< 3.0	35	36.0	32.0	37.0
0007	< 0.00	< 3.0	< 3.0	10	< 3.0	< 3.0	13	12.0	13.0	19.0
0010	< 0.00	< 3.0	4.0	8	< 3.0	< 3.0	10	12.0	11.0	16.0
0011	< 0.00	< 3.0	8.0	6	< 3.0	< 3.0	13	16.0	9.0	20.0
0013	< 0.00	< 3.0	< 3.0	6	< 3.0	< 3.0	10	8.0	9.0	14.0

KEY: < Less than detection limit

NICKEL

STATION	I0	F1	F2	F3	F4	SED	MAX	SUB	F3 + F4 SUB F1-F4
0000	0.00	3.0	< 2.00	< 3.0	< 3.0	3.0	0	0	6.0	9.0
0001	< 0.00	4.0	< 2.00	4.0	< 3.0	< 3.0	7	12	6.0	12.0
0002	< 0.00	3.0	< 2.00	4.0	< 3.0	4.0	5	11	6.0	11.0
0003	0.07	3.0	< 2.00	4.0	< 3.0	4.0	8	11	6.0	11.0
0004	< 0.00	3.0	< 2.00	5.0	< 3.0	5.0	10	13	7.0	12.0
0005	0.07	< 3.0	< 2.00	5.0	< 3.0	4.0	9	13	7.0	11.0
0006	< 0.00	< 3.0	< 2.00	3.0	< 3.0	3.0	0	0	0.0	0.0
0012	< 0.00	< 3.0	< 2.00	< 3.0	< 3.0	< 3.0	3	3	4.0	6.0
0005	< 0.00	< 3.0	< 2.00	< 3.0	< 3.0	< 3.0	0	2	4.0	6.0
0009	0.07	< 3.0	< 2.00	< 3.0	< 3.0	< 3.0	10	10	4.0	8.0
0014	0.06	< 3.0	< 2.00	0.0	< 3.0	3.0	11	13	10.0	14.0
0007	< 0.00	3.0	< 2.00	4.0	< 3.0	< 3.0	7	7	6.0	11.0
0010	0.06	< 3.0	< 2.00	3.0	< 3.0	3.0	5	6	0.0	0.0
0011	< 0.00	< 3.0	< 2.00	3.0	< 3.0	< 3.0	6	3	3.0	9.0
0013	0.06	< 3.0	< 2.00	3.0	< 3.0	< 3.0	0	3	3.0	9.0

KEY: < Less than detection limit

MANGANESE

STATION	I0	F1	F2	F3	F4	SED	MAX	SUB	F3 + F4 SUB F1-F4
0000	0.00	83.0	83.3	10.9	9.7	36.7	366.0	494.5	31.6	180.6
0001	0.09	74.4	67.1	30.7	10.1	60.1	139.0	300.3	35.6	177.3
0002	4.53	107.0	95.6	30.8	4.4	46.4	200.0	477.0	38.3	186.0
0003	4.38	94.4	44.9	15.6	3.6	73.8	391.0	488.7	28.4	119.7
0004	3.15	53.9	91.7	26.6	6.0	64.7	303.0	383.2	32.6	170.2
0005	3.89	23.0	79.4	13.6	3.5	126.0	213.0	331.5	16.1	110.5
0006	1.75	18.7	76.8	9.3	2.1	91.6	234.0	330.3	11.6	106.3
0012	1.98	8.7	81.9	9.9	1.0	88.9	186.0	178.1	11.7	78.1
0005	1.38	48.9	17.9	6.6	1.0	16.9	94.0	104.5	8.4	66.9
0009	7.75	3.3	33.3	4.3	1.2	8.8	499.0	499.5	5.5	48.9
0014	2.53	7.7	100.0	33.0	4.4	34.6	229.0	431.5	39.6	383.5
0007	3.64	36.6	39.4	7.6	1.6	34.6	133.0	197.3	9.2	75.3
0010	3.21	64.3	29.3	10.0	1.0	37.7	127.0	233.0	11.0	109.4
0011	3.19	34.3	34.2	11.0	3.0	17.0	99.3	154.6	15.0	75.3
0013	2.09	6.1	43.6	6.1	1.5	31.2	168.0	218.3	9.6	56.3

KEY: < Less than detection limit

ZINC

STATION	I0	F1	F2	F3	F4	SED	MAX	SUB	F3 + F4 SUB F1-F4
0000	0.03	1.6	9.4	8.9	3.0	18.7	39.0	36.2	12.0	33.0
0001	0.07	7.6	8.1	49.7	36.9	11.3	139.0	101.7	76.6	98.5
0002	< 0.03	1.7	8.3	29.3	6.1	9.8	36.0	44.3	36.4	36.4
0003	0.04	4.2	32.3	91.3	3.6	10.6	97.3	91.9	96.9	91.3
0004	< 0.01	6.6	13.5	87.1	5.1	19.6	87.9	93.1	63.2	81.9
0005	< 0.03	4.0	13.7	13.1	3.0	11.2	27.6	45.0	16.1	33.6
0006	< 0.03	4.0	15.9	19.1	3.2	8.2	38.2	46.4	18.3	36.2
0012	0.03	1.6	7.1	9.6	1.9	6.6	32.6	36.7	11.3	30.1
0005	< 0.02	6.6	6.1	7.9	4.1	6.1	40.1	40.7	10.0	15.6
0009	< 0.02	4.6	4.9	6.9	4.1	4.6	93.6	15.2	7.8	14.6
0014	< 0.01	3.6	48.9	43.3	3.6	8.2	83.7	86.5	36.9	96.2
0007	< 0.01	1.6*	8.6	9.8	1.9	4.2	39.2	38.6	11.6	31.2
0010	< 0.02	6.6	6.9	11.5	4.2	4.6	68.9	28.9	13.7	21.8
0011	0.08	8.6	10.0	9.3	2.3	3.7	33.6	28.9	11.6	33.2
0013	< 0.01	1.5	6.6	8.1	1.2	4.1	33.6	31.3	9.3	17.3

KEY: < Less than detection limit

table 8 In-Place Pollutants Program

SEDIMENT - PCBs and Pesticides

Rice Lake - Otonabee R 1987

UNITS: ng/g dry weight

Station #	Aldrin	A-BHC Hexachlorocyclohexane	B-BHC Hexachlorocyclohexane	G-BHC Hexachlorocyclohexane	A-Chlordane	G-Chlordane	Dieldrin	DMDT methoxychlor	Endosulfan I	Endosulfan II	Endrin	Endosulfan sulfate	Heptachlor epoxide	Heptachlor	Mirex	Oxychlordane	OP-DDT		PCB total	PP-DDD	PP-DDE	PP-DDT	Hexachlorobenzene
0002	<1	<1	<1	3	<2	<2	<2	<3	<2	<4	<4	<4	8	<1	<5	<2	<5		<20	<5	3	<5	<1
0015	<1	<1	<1	<1	<3	<2	<2	<5	<2	<4	<4	<4	<1	<1	<5	<2	<5		<20	10	<1	<5	<1
0001	<1	<1	<1	3	<2	<2	<2	<5	<2	<4	<4	<4	8	<1	<5	<2	<5		<20	<5	3	<5	<1
0003	<1	<1	<1	2	<2	<2	<2	<3	<2	<4	<4	<4	3	<1	<5	<2	<5	P51	880	<5	<1	<5	<1
0004	<1	<1	2	<1	<2	<2	<2	<3	<2	<4	<4	<4	<1	<1	<5	<2	<5	P51	6140	<5	<1	<5	<1
0005	<1	<1	<1	<1	<2	<2	<2	<3	<2	<4	<4	<4	<1	<1	<5	<2	<5		<20	<5	<1	<5	<1
0008	<1	<1	<1	<1	<2	<3	<2	<3	<2	<4	<4	<4	<1	<1	<5	<3	<5	P51	1300	<5	<1	<5	<1
0012	<1	<1	<1	8	<2	<2	<2	<5	<7	<4	<4	<4	<1	<1	<5	<2	<5	P51	925	<5	19	<5	<1
0006	<1	<1	<1	3	<2	<2	<2	<3	<2	<4	<4	<4	<1	<1	<5	<2	<5	P51	830	<5	<1	<5	<1
0009	<1	<1	<1	2	<2	<2	<2	<3	<2	<4	<4	<4	<1	<1	<5	<2	<5	P51	1370	<5	<1	<5	<1
0014	<1	<1	<1	2	<2	<2	<2	<5	<2	5	<4	<4	<1	<1	<5	<2	<5	P51	1160	<5	24	<5	<1
0007	<1	<1	<1	6	<2	<2	<2	<3	<2	<4	<4	<4	<1	<1	<5	<2	<5	P51	490	<5	<1	<5	<1
0010	<1	<1	<1	2	<2	<2	<2	<5	<2	<4	<4	<4	<1	<1	<5	<3	<5	P51	515	<5	12	<5	<1
0011	<1	<1	<1	3	<2	<2	<2	<5	<2	<4	<4	<4	<1	<1	<5	<2	<5	P51	275	<5	9	<5	<1
0013	<1	<1	<1	<1	<2	<2	<2	<5	<2	<4	<4	<4	<1	<1	<5	<2	<5	P51	280	<5	8	<5	<1

KEY < LOWER THAN DETECTION LIMIT

<1 THIS LOW MEASUREMENT IS TENTATIVE - FOR INFORMATION ONLY

- NO DATA

P40 PCB RESEMBLED MIXTURE OF AROCLOR 1254 AND 1260

P54 PCB RESEMBLED AROCLOR 1254

P51 PCB RESEMBLED MIXTURE OF AROCLOR 1248 1254 AND 1260

Table 9 : In-Place Pollutants Program

Rice Lake - Otonabee R. 1987

SEDIMENT - PAHs

UNITS: ug/g dry weight

Station #	Dibenzo(a,h) anthracene	Benzo(g,h,i) perylene	Naphtha-lene	Acenaph-thylene	Acenaph-thene	Fluorene	Phenan-threne	Anthracene	Fluoran-threne	Pyrene	Benzo(a) anthracene	Chrysene	Benzo(k) fluoran-thene	Benzo(b) fluorene	Benzo(a) pyrene	Indeno (1,2,3-cd) pyrene
0001	0.94	1.62	0.47	0.08	0.74	1.20	8.79	1.94	10.63	6.76	2.90	3.17	4.51	4.51	2.47	1.61
0003	0.25	0.53	0.05	0.04 <T	0.06	0.11	1.20	0.24	1.66	1.36	0.60	0.64	1.19	1.19	0.67	0.51
0004	0.09	0.59	0.04 <T	0.07	0.04 <T	0.04	0.56	0.11	0.98	0.86	0.62	0.65	0.71	0.71	0.86	0.58
0006	0.04 <T	0.13	0.04 <T	0.04 <T	0.04 <T	0.04 <T	0.07 <T	0.01 <T	0.17	0.16	0.07	0.11	0.15	0.15	0.15	0.07
0007	0.04 <T	0.18	0.04 <T	0.04 <T	0.04 <T	0.04 <T	0.07 <T	0.01 <T	0.14	0.14	0.09	0.12	0.17	0.17	0.18	0.15
0008	0.04	0.23	0.04 <T	0.04 <T	0.04 <T	0.04 <T	0.16	0.04	0.36	0.33	0.34	0.26	0.32	0.32	0.36	0.23
0011	0.04 <T	0.38	0.04 <T	0.04 <T	0.04 <T	0.04 <T	0.07 <T	0.01 <T	0.20	0.19	0.13	0.15	0.24	0.24	0.21	0.35
0012	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0013	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

KEY: <T - A measurable trace amount

- - No data

able 10 In-Place Pollutants Program
SEDIMENT - Organics
Rice Lake - Otonabee R 1987
Units ng/g dry weight

Station	Dicamba	Hexa-chloro ethane	1 3 5 Trichloro benzene	1 2 4 Trichloro benzene	Hexa Chloro-butadiene	1 2 3 Trichloro benzene	2 4 5 Trichloro toluene	2 3 6 Trichloro toluene	1 2 3 5 Tetrachloro benzene	1 2 4 5 Tetrachloro benzene	2 6 Trichloro toluene	Tetra-chloro-benzene	Penta-chloro-benzene	2 4 DI Propionic Acid	2 4-Dichloro-Phenoxy-Acetic Acid	Silvex	2 4 5-Trichloro-Phenoxy-Acetic Acid	2 4-Dichloro-Phenoxy-Butyric Acid	Picloram
0002	-	<1	<2	<2	<1	<2	<1	<1	<1	<1	<1	<1	<1	-	-	-	-	-	-
0015	-	<1	<2	<2	<1	<2	<1	<1	<1	<1	<1	<1	<1	-	-	-	-	-	-
0001	<100	<1	<2	<2	<1	<2	<1	<1	<1	<1	<1	<1	<1	<100	<100	<50	<50	<200	<100
0003	<100	<1	<2	<2	<1	<2	<1	<1	<1	<1	<1	<1	<1	<100	<100	<50	<50	<200	<100
0004	<100	<1	<2	<2	<1	<2	<1	<1	<1	<1	<1	<1	<1	<100	<100	<50	<50	<200	<100
0005	-	<1	<2	<2	<1	<2	<1	<1	<1	<1	<1	<1	<1	-	-	-	-	-	-
0008	<100	<1	<2	<2	<1	<2	<1	<1	<1	<1	<1	<1	<1	<100	<100	<50	<50	<200	<100
0012	-	<1	<2	<2	<1	<2	<1	<1	<1	<1	<1	<1	<1	-	-	-	-	-	-
0006	<100	<1	<2	<2	<1	<2	<1	<1	<1	<1	<1	<1	<1	<100	<100	<50	<50	<200	<100
0009	-	<1	<2	<2	<1	<2	<1	<1	<1	<1	<1	<1	<1	-	-	-	-	-	-
0014	-	<1	<2	<2	<1	<2	<1	<1	<1	<1	<1	<1	<1	-	-	-	-	-	-
0007	<100	<1	<2	<2	<1	<2	<1	<1	<1	<1	<1	<1	<1	<100	<100	<50	<50	<200	<100
0010	-	<1	<2	<2	<1	<2	<1	<1	<1	<1	<1	<1	<1	-	-	-	-	-	-
0011	<100	<1	<2	<2	<1	<2	<1	<1	<1	<1	<1	<1	<1	<100	<100	<50	<50	<200	<100
0013	-	<1	<2	<2	<1	<2	<1	<1	<1	<1	<1	<1	<1	-	-	-	-	-	-

KEY < LOWER Than DETECTION LEVEL
- NO Data

TABLE 11. Benthic Invertebrates - Tissue-Sediment Concentration Ratios
Otonabee R. and Rice L.

Station No.	Copper	Chromium	Mercury	Cadmium	Iron	Lead
0003	0.25	0.10	0.747	0.526	0.23	0.12
0003	0.26	0.14	0.793	0.573	0.23	0.13
0004	1.64	0.59	1.618	5.340	0.32	1.32
0005	2.54	0.44	5.133	2.650	0.24	1.57
0005	2.68	0.55	4.500	2.680	0.31	1.74
0008	0.4	0.15	0.333	0.281	0.13	0.18
0012	0.21	0.11	0.261	0.282	0.10	0.08
0006	0.35	0.04	0.404	0.299	0.12	0.07
0009	0.27	0.02	0.283	0.154	0.06	0.04
0014	0.21	0.11	0.225	0.143	0.10	0.08
0007	0.50	0.06	0.575	0.492	0.14	0.14
0010	0.36	0.16	0.462	0.515	0.10	0.15
0011	0.17	0.09	0.262	0.217	0.14	0.07
0013	0.28	0.12	0.517	0.215	0.15	0.09

Station No.	Zinc	Arsenic	Manganese	Aluminum	Nickel	PCB*
0015						103.8
0001						28.3
0003	0.35	2.25	0.30	0.71	0.20	1.0
0003	0.37	0.97	0.31	0.72	0.13	
0004	1.64	0.55	1.64	0.21	0.44	0.01
0005	7.30	0.47	0.88	0.25	0.68	28.3
0005	6.93	0.47	1.06	0.32	0.86	
0008	0.59	0.08	0.59	0.09	0.14	0.05
0012	0.25	0.07	0.77	0.03	0.07	4.62
0006	0.34	0.00	0.26	0.01	0.02	0.2
0009	0.41	0.11	0.07	0.00	0.06	0.14
0014	0.14	0.03	0.70	0.03	0.09	0.05
0007	0.53	0.10	0.49	0.01	0.07	0.13
0010	0.44	0.07	1.05	0.03	0.07	0.24
0011	0.51	0.06	0.55	0.02	0.07	0.23
0013	0.38	0.07	0.59	0.04	0.09	1.57

Sediment concentrations used in the calculations were on a dry weight (ug/g) basis. Biota values used were wet weight converted to dry weight and corrected for gut contents according to the formula in Persaud et al (1987). Gut corrected tissue concentrations were computed according to the formula:

$$C_{ct} = C_{org} - (C_{sed} \times K_{ash}) \times (1 - K_{ash})^{-1}$$

where C_{ct} = gut corrected tissue concentration; C_{org} = organism (dry weight) contaminant concentration; C_{sed} = bulk sediment concentration and; K_{ash} = residue after ashing organism at 500° C (as a percentage).

Tissue-sediment concentration ratios were computed according to the formula:

$$Ratio = C_{ct} / C_{sed}$$

* Dry weight not corrected for gut contents

Table 12: In-Place Pollutants Program
BENTHIC INVERTEBRATES - Metals
Rice Lake - Otonabee R. 1987
UNITS: ug/g wet weight (Not corrected for gut content)

Station #	Biota	Aluminum	Arsenic	Cadmium	Chromium	Copper	Iron	Lead	Manganese	Mercury	Nickel	Zinc
0003	Chironomids	136	0.53	0.094	0.72	3.50	744	3.56	24.4	0.018	0.49	11.7
0003	Chironomids	139	0.23	0.102	0.90	3.66	755	3.78	25.6	0.019	0.33	12.1
0004	Chironomids	148	0.10	0.165	2.01	5.67	546	3.32	51.4	0.028	0.65	15.7
0005	Hexagenia	176	< 0.05	0.083	1.01	3.54	346	2.97	26.7	0.024	0.78	37.5
0005	Hexagenia	223	< 0.05	0.084	1.25	3.73	440	3.29	31.9	0.021	0.98	35.6
0008	Chironomids	126	< 0.03	0.085	1.00	2.19	333	1.48	42.0	0.010	0.47	10.4
0012	Chironomids	97	< 0.05	0.102	1.00	1.80	461	1.08	76.2	0.012	0.35	6.2
0006	Chironomids	50	< 0.01	0.083	0.41	2.67	455	0.82	23.7	0.015	0.15	7.2
0009	Chironomids	21	< 0.05	0.064	0.24	2.18	190	0.60	5.8	0.011	0.23	9.8
0014	Chironomids	104	< 0.03	0.077	1.21	2.21	450	1.44	79.2	0.012	0.43	4.5
0007	Chironomids	37	< 0.05	0.072	0.38	2.39	395	0.73	20.3	0.011	0.24	7.7
0010	Chironomids	84	< 0.05	0.108	0.93	1.90	351	0.83	83.7	0.012	0.27	6.8
0011	Chironomids	76	< 0.05	0.065	0.67	1.30	515	0.67	44.0	0.009	0.35	10.7
0013	Chironomids	85	< 0.04	0.043	0.60	1.26	466	0.78	41.6	0.010	0.31	5.6

KEY: < Less than detection limit

Table 13: In-Place Pollutants Program

BENTHIC INVERTEBRATES - PCBs & Pesticides

Rice Lake - Otonabee R 1987

Units: ug/g wet weight (not corrected for gut content)

Station	Biota	HCB	Hepta-chlor	Hepta-chlor epoxide	Aldrin	Alrex	A-BHC	B-BHC	D-BHC	A-Chlor-dane	G-Chlor-dane	PCB	Oxy-chlo.dane	PP-DDE	PP-DDD	PP-DDT	OP-DDT	Endo-sulfan I	Endo-sulfan II	Dieldrin	Endrin	Endo-sulfan sulfate	Methoxy-chlor	% Lipid	% Ash
0010	Chironomids	< 0.001	< 0.001	< 0.002	< 0.001	< 0.002	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.33	-	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.010	< 0.001	< 0.001	0.141	0.97
0001	Chironomids	< 0.001	< 0.001	< 0.002	< 0.001	< 0.002	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.09	-	< 0.001	0.003	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.010	< 0.001	< 0.001	0.059	2.10
0003	Chironomids	< 0.001	< 0.001	< 0.002	< 0.001	< 0.002	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.14	-	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.005	< 0.001	< 0.001	0.160	2.30
0004	Chironomids	< 0.001	< 0.001	< 0.002	< 0.001	< 0.002	< 0.001	< 0.001	0.002	< 0.001	< 0.001	< 0.01	-	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.010	< 0.001	< 0.001	0.155	3.67
0004	Lumbricids	< 0.001	< 0.001	< 0.002	< 0.001	< 0.002	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.01	-	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.010	< 0.001	< 0.001	0.244	3.36
0005	Hexagenia	< 0.001	< 0.001	< 0.002	< 0.001	< 0.002	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.09	-	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.010	< 0.001	< 0.001	0.744	2.42
0006	Chironomids	< 0.001	< 0.001	< 0.002	< 0.001	< 0.002	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.01	-	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.010	< 0.001	< 0.001	0.013	2.20
0006	Chironomids	< 0.001	< 0.001	< 0.002	< 0.001	< 0.002	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.06	-	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.010	< 0.001	< 0.001	0.026	1.31
0009	Chironomids	< 0.001	< 0.001	< 0.002	< 0.001	< 0.002	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.02	-	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.010	0.006	< 0.001	0.630	1.12
0014	Chironomids	< 0.001	< 0.001	< 0.002	< 0.001	< 0.002	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.03	-	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.010	< 0.001	< 0.001	0.406	0.83
0007	Chironomids	0.007	< 0.001	0.007	< 0.001	< 0.002	0.006	< 0.001	< 0.001	< 0.001	< 0.001	< 0.01	-	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.010	< 0.001	< 0.001	0.059	1.09
0010	Chironomids	< 0.001	< 0.001	< 0.002	< 0.001	< 0.002	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.01	-	< 0.001	0.002	< 0.001	< 0.001	< 0.001	0.002	< 0.001	< 0.010	< 0.001	< 0.001	0.324	1.09
0011	Chironomids	< 0.001	< 0.001	< 0.002	< 0.001	< 0.003	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.02	-	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.010	< 0.001	< 0.001	0.068	1.44
0013	Chironomids	< 0.001	< 0.001	< 0.002	< 0.001	< 0.002	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.01	-	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.010	< 0.001	< 0.001	0.141	1.33
		0.07	-	< 0.001	0.002	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.010	< 0.001	< 0.001	0.229	1.35

KEY: < Less than detection limit

- No data

Table 14: In-Place Pollutants Program
BENTHIC INVERTEBRATES - Chlorinated Aromatics
Rice Lake - Otonabee R. 1987
UNITS: ug/g wet weight (Not corrected for gut content)

Station	Biota	Hexa-chloro-ethane	1.3.5. Trichloro-benzene	1.2.4 Trichloro-benzene	Hexa-chloro-butadiene	1.2.3 Trichloro-benzene	2.4.5 Trichloro-toluene	2.3.6 Trichloro-toluene	1.2.3.5 Tetrachloro-benzene	1.2.4.5 Tetrachloro-benzene	2.6A Trichloro-toluene	1.2.3.4 Tetrachloro-benzene	Pentachloro-benzene	Octachloro-styrene	Toxaphene
0015	Chironomids	< 0.001	< 0.010	< 0.01	< 0.001	< 0.005	-	-	< 0.001	< 0.001	< 0.01	< 0.001	< 0.001	-	< 0.01
0001	Chironomids	< 0.001	< 0.010	< 0.01	< 0.001	< 0.005	-	-	< 0.001	< 0.001	< 0.01	< 0.001	< 0.001	-	< 0.01
0003	Chironomids	< 0.001	< 0.010	< 0.01	< 0.001	< 0.005	-	-	< 0.001	< 0.001	< 0.01	< 0.001	< 0.001	-	< 0.01
0004	Chironomids	< 0.001	< 0.010	< 0.01	< 0.001	< 0.005	-	-	< 0.001	< 0.001	< 0.01	< 0.001	< 0.001	-	< 0.01
0004	Lumbricids	< 0.001	< 0.010	< 0.01	< 0.001	< 0.005	-	-	< 0.001	< 0.001	< 0.01	< 0.001	< 0.001	-	< 0.01
0005	Hexagenia	< 0.001	< 0.010	< 0.01	< 0.001	< 0.005	-	-	< 0.001	< 0.001	< 0.01	< 0.001	< 0.001	-	< 0.01
0006	Chironomids	< 0.001	< 0.010	< 0.01	< 0.001	< 0.005	-	-	< 0.001	< 0.001	< 0.01	< 0.001	< 0.001	-	< 0.01
0012	Chironomids	< 0.001	< 0.010	< 0.01	< 0.001	< 0.005	-	-	< 0.001	< 0.001	< 0.01	< 0.001	< 0.001	-	< 0.01
0006	Chironomids	< 0.001	< 0.010	< 0.01	< 0.001	< 0.005	-	-	< 0.001	< 0.001	< 0.01	< 0.001	0.004	-	< 0.01
0009	Chironomids	< 0.001	< 0.010	< 0.01	< 0.001	< 0.005	-	-	< 0.001	< 0.001	< 0.01	< 0.001	< 0.001	-	< 0.01
0014	Chironomids	< 0.001	< 0.010	< 0.01	< 0.001	< 0.005	-	-	< 0.001	< 0.001	< 0.01	< 0.001	< 0.001	-	< 0.01
0007	Chironomids	< 0.001	< 0.010	< 0.01	< 0.001	< 0.005	-	-	< 0.001	< 0.001	< 0.01	< 0.001	< 0.001	-	< 0.01
0010	Chironomids	< 0.001	< 0.010	< 0.01	0.002	< 0.002	-	-	< 0.001	< 0.001	< 0.01	< 0.001	< 0.001	-	< 0.01
0011	Chironomids	< 0.001	< 0.002	< 0.01	< 0.001	< 0.005	-	-	< 0.001	< 0.001	< 0.01	< 0.001	< 0.001	-	< 0.01
0013	Chironomids	< 0.001	< 0.010	< 0.01	< 0.001	< 0.005	-	-	< 0.001	< 0.001	< 0.01	< 0.001	< 0.001	-	< 0.01

KEY: < Less than detection limit
- no data

Table 19: In-Place Pollutants Program
FISH - Metals
Rice Lake - Otonabee R. 1987
UNITS: ug/g wet weight

Station	Species	Age (Yrs)	Alum-inum	Arsenic	Cadmium	Chromium	Copper	Iron	Lead	Mang-anese	Mercury	Nickel	Zinc	% Solids
Control	C.bairdi	YOY-1	32.0	0.41	0.036	1.10	9.54	35.0	0.34	7.50	0.031	0.80	35.80	25.24
1a	C.bairdi	3-4	18.0	0.42	0.015	0.61	4.71	42.0	0.39	2.30	0.051	0.47	34.00	25.62
1b	C.bairdi	2-3	15.0	0.34	0.016	0.57	5.01	29.0	0.38	2.60	0.035	0.35	29.10	25.32
3	C.bairdi	YOY-1	13.0	0.27	0.025	0.62	5.95	18.0	0.51	1.60	0.042	0.43	31.10	26.71
3	Bluntnose minnow	1	14.0	0.22	0.029	0.69	6.60	27.0	0.33	5.40	0.048	0.51	43.20	24.47
4	C.bairdi	3-4	13.0	0.37	0.013	0.59	4.30	25.0	0.40	3.70	0.039	0.41	25.20	25.86
11c	C.bairdi	2-3	12.0	0.18	0.044	0.51	4.64	16.0	0.26	2.80	0.023	0.48	17.80	27.33
11c	C.bairdi	2-3	12.0	0.18	0.011	0.57	4.97	15.0	0.10	2.60	0.021	0.48	17.30	26.06

Table 16: In-Place Pollutants Program
FISH - PCBs & Pesticides
Rice Lake - Otonabee R. 1987
UNITS: ug/g wet weight

Station #	Biota	Age	PCB	Hepta-chlor	Hepta-chlor epoxide	Aldrin	Alrex	A-BHC	B-BHC	D-BHC	A-Chlor-dane	G-Chlor-dane	PCB	Oxy-chlordane	PP-DDE	PP-DDD	PP-DDT	OP-DDT	Endo-sulfan I	Endo-sulfan II	Dieldrin	Endrin	Endo-sulfan sulfate	Methoxy-Chlor	% Lipid	% Ash
Control	C. bairdi	YOY-1	< 0.001	< 0.001	< 0.002	< 0.001	< 0.002	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.01		< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.010	< 0.001	< 0.001	0.141	
10	C. bairdi	3+5	< 0.001	0.004	< 0.002	< 0.001	< 0.002	< 0.001	< 0.001	0.037	< 0.001	< 0.001	0.23	-	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.010	< 0.001	< 0.001	0.141	0.97
9b	C. bairdi	2+3	< 0.001	< 0.001	< 0.002	< 0.001	< 0.002	0.002	< 0.001	0.003	< 0.001	< 0.001	0.09	-	0.006	0.003	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.010	0.003	< 0.001	0.099	2.10
0003	C. bairdi	YOY-1	< 0.001	< 0.001	< 0.002	< 0.001	< 0.002	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.14	-	0.032	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.005	< 0.001	< 0.001	0.100	2.28
0003	C. bairdi	1	< 0.001	< 0.001	< 0.002	< 0.001	< 0.002	< 0.001	< 0.001	0.002	< 0.001	< 0.001	< 0.01	-	0.008	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.010	< 0.001	< 0.001	0.155	3.47
0004	C. bairdi	3+4	< 0.001	< 0.001	< 0.002	< 0.001	< 0.002	0.005	< 0.001	0.006	< 0.001	< 0.001	< 0.01	-	0.006	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.010	< 0.001	< 0.001	0.244	3.20
11C	C. bairdi	3+3	< 0.001	< 0.001	< 0.002	< 0.001	< 0.002	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.09	-	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.010	< 0.001	< 0.001	0.760	2.48

KEY: < Less than detection limit
- no data

Table 17: In-Place Pollutants Program
FISH - Chlorinated Aromatics
Rice Lake - Otonabee R. 1987
UNITS: ug/g wet weight

Station	Biota	Age (yrs)	Hexa-chloro-ethane	1,3,5-Trichloro-benzene	1,2,4 Trichloro-benzene	Hexa-chloro-butadiene	1,2,3 Trichloro-benzene	2,4,5 Trichloro-toluene	2,3,6 Trichloro-toluene	1,2,3,5 Tetrachloro-benzene	1,2,4,5 Tetrachloro-benzene	2,6A Trichloro-toluene	1,2,3,4 Tetrachloro-benzene	Pentachloro-benzene	Octachloro-styrene	Texaphene
Control	C. bairdi	YOY-1	0.011	< 0.010	< 0.01	< 0.001	0.012	-	-	< 0.001	< 0.001	< 0.01	< 0.001	< 0.001	-	< 0.01
10	C. bairdi	3+5	0.005	< 0.010	< 0.01	0.006	0.006	-	-	< 0.001	< 0.001	< 0.01	< 0.001	< 0.001	-	< 0.01
9b	C. bairdi	2+3	0.004	< 0.010	< 0.01	0.004	0.004	-	-	< 0.001	< 0.001	< 0.01	0.007	< 0.001	-	< 0.01
0003	C. bairdi	YOY-1	< 0.001	< 0.010	< 0.01	< 0.001	< 0.001	-	-	< 0.001	< 0.001	< 0.01	< 0.001	< 0.001	-	< 0.01
0003	C. bairdi	1	0.004	< 0.010	< 0.01	< 0.001	< 0.001	-	-	< 0.001	< 0.001	< 0.01	< 0.001	< 0.001	-	< 0.01
0004	C. bairdi	3+4	0.006	< 0.010	< 0.01	0.008	0.008	-	-	< 0.001	< 0.001	< 0.01	< 0.001	< 0.001	-	< 0.01
11C	C. bairdi	3+3	0.008	< 0.010	< 0.01	< 0.001	< 0.001	-	-	< 0.001	< 0.001	< 0.01	< 0.001	< 0.001	-	< 0.01

KEY: < Less than detection limit
- no data

Table 18: In-Place Pollutants Program
Sediment Bioassay Bioaccumulation Results: Metals
Rice Lake - Otonabee R. 1987
UNITS: ug/g wet weight (not corrected for gut content)

LOCATION	STATION	ORGANISM	(% Solids)	Al	As	Cd	Cr	Cu	Fe	Pb	Mn	Hg	Ni	Zn
RICE LAKE	CONTROL	MAYFLIES	11.85	219	0.15	0.143	0.84	1.76	414	0.67	22.0	0.012	0.68	22.1
RICE LAKE	CONTROL B	FATHEADS	23.47	98	0.19	0.098	0.65	6.68	185	0.40	5.9	0.252	0.54	44.9
RICE LAKE	15	MAYFLIES	14.88	158	0.12	0.171	0.47	1.70	273	0.94	20.4	0.014	0.13	24.9
RICE LAKE	15A	FATHEADS	26.66	25	0.06	0.053	0.50	6.10	43	0.24	1.5	0.240	0.11	36.8
RICE LAKE	15A	FATHEADS	26.56	44	0.06	0.077	0.51	7.46	66	0.24	2.4	0.205	0.17	41.7
RICE LAKE	1	MAYFLIES	13.36	109	0.32	0.230	1.01	8.56	367	9.05	11.1	0.021	0.32	32.6
RICE LAKE	1C	FATHEADS	25.36	56	0.28	0.140	0.90	14.75	256	5.42	4.7	0.154	0.33	47.0
RICE LAKE	3	MAYFLIES	13.21	116	0.22	0.166	0.82	3.48	248	3.54	11.2	0.015	0.64	27.3
RICE LAKE	3A	FATHEADS	22.51	34	0.10	0.075	0.54	7.11	66	1.22	2.3	0.221	0.16	38.7
RICE LAKE	4	MAYFLIES	15.71	109	0.28	0.226	1.06	5.00	280	2.87	18.4	0.028	0.44	34.4
RICE LAKE	4A	FATHEADS	34.91	81	0.18	0.129	4.65	12.18	209	2.19	9.1	0.308	1.01	61.4
RICE LAKE	5	MAYFLIES	15.19	134	0.21	0.194	0.89	2.78	303	1.60	18.6	0.017	0.57	29.0
RICE LAKE	5A	FATHEADS	27.22	21	0.16	0.058	0.30	6.62	56	0.27	2.1	0.252	0.13	44.2
RICE LAKE	8	MAYFLIES	12.27	81	0.19	0.172	0.84	2.34	193	1.08	13.0	0.017	0.44	24.1
RICE LAKE	8A	FATHEADS	23.63	20	0.24	0.084	0.54	6.76	67	0.51	2.6	0.160	0.38	36.8
RICE LAKE	12	MAYFLIES	12.20	84	0.30	0.181	0.77	2.06	172	0.60	11.3	0.019	0.27	24.6
RICE LAKE	12A	FATHEADS	26.51	15	0.16	0.065	0.33	6.89	28	0.10	0.8	0.172	< 0.10	26.5
RICE LAKE	6	MAYFLIES	12.99	65	0.20	0.141	0.58	1.96	135	0.56	6.4	0.016	0.46	23.5
RICE LAKE	6A	FATHEADS	23.38	89	0.14	0.098	0.89	6.67	146	0.65	4.2	0.149	0.51	30.8
RICE LAKE	9	MAYFLIES	14.46	112	0.18	0.162	1.16	2.43	233	1.43	16.3	0.018	0.53	23.9
RICE LAKE	9C	FATHEADS	25.25	29	0.21	0.063	0.82	6.43	64	0.51	2.5	0.252	0.36	35.7
RICE LAKE	14	MAYFLIES	14.47	135	0.11	0.203	1.22	3.17	285	1.84	29.3	0.020	0.87	28.2
RICE LAKE	14A	FATHEADS	23.93	70	0.11	0.076	0.85	6.41	122	0.76	5.8	0.139	0.33	32.9
RICE LAKE	7	MAYFLIES	18.11	60	0.46	0.239	0.77	4.07	210	0.43	10.2	0.018	0.58	29.4
RICE LAKE	7A	FATHEADS	22.06	58	0.39	0.110	0.95	9.12	187	0.20	8.7	0.285	0.13	44.3
RICE LAKE	10	MAYFLIES	14.23	74	0.23	0.191	0.51	2.12	170	0.46	14.0	0.018	0.40	26.0
RICE LAKE	10A	FATHEADS	24.90	34	0.27	0.056	0.63	6.65	64	0.20	2.5	0.130	0.19	30.7
RICE LAKE	11	MAYFLIES	13.15	65	0.27	0.248	0.68	2.02	133	0.56	6.9	0.019	0.37	30.0
RICE LAKE	11A	FATHEADS	29.86	54	0.05	0.099	0.54	5.27	105	0.40	3.3	0.123	0.19	23.5
RICE LAKE	11A	FATHEADS	24.32	26	0.15	0.050	0.52	6.56	91	0.31	1.5	0.121	0.37	31.3

KEY: < Less than detection limit

Table 10: 10-Place Pollutants Program
Sediment Bioassay Bioaccumulation Results: PCBs & Pesticides
Eice Lake - December 8 1987
Units: ug/g wet weight (not corrected for gut content)

Location	Station	Organism	weight(g)	% Lipid	% ash	HCB	Hepta Chlor	Hepta epox	oldrin	dieldrin	p-BHC	B-BHC	G-BHC	Alpha-Chlordane	Gamma-Chlordane	Oxy-Chlordane	pp-DDE	pp-DDD	pp-DDT	op-DDT	a-Endo-sulfan	B-Endo-sulfan	Dieldrin	Endrin	Endo-SO4	Methoxy-chlor	PCB
EICE LAKE	CONTROL	ANNELIDS	1.103	2.367	2.13	0.000	< 0.001	< 0.002	0.002	< 0.002	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	-	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.01	< 0.001	< 0.001	< 0.01
EICE LAKE	CONTROL D	FATHEADS	0.756	3.290	3.70	< 0.001	< 0.001	< 0.002	< 0.001	< 0.002	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	-	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.01	< 0.001	< 0.001	< 0.01
EICE LAKE	10	ANNELIDS	1.222	2.322	2.00	< 0.001	< 0.001	< 0.002	< 0.001	< 0.002	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	-	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.01	< 0.001	< 0.001	< 0.01
EICE LAKE	10A	FATHEADS	1.340	5.240	3.47	0.000	< 0.001	< 0.002	< 0.001	< 0.002	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	-	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.01	< 0.001	< 0.001	< 0.01
EICE LAKE	1	ANNELIDS	0.963	1.017	1.17	< 0.001	< 0.001	< 0.002	< 0.001	< 0.002	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	-	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.01	< 0.001	< 0.001	< 0.01
EICE LAKE	1C	FATHEADS	0.536	2.230	3.76	< 0.001	< 0.001	< 0.002	< 0.001	< 0.002	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	-	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.01	< 0.001	< 0.001	< 0.01
EICE LAKE	3	ANNELIDS	1.133	2.270	1.75	< 0.001	< 0.001	< 0.002	< 0.001	< 0.002	< 0.001	< 0.001	< 0.731	< 0.001	< 0.001	-	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.01	< 0.001	< 0.001	< 0.01
EICE LAKE	3A	FATHEADS	0.750	3.307	3.65	< 0.001	< 0.001	< 0.002	< 0.001	< 0.002	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	-	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.01	< 0.001	< 0.001	< 0.01
EICE LAKE	4	ANNELIDS	1.115	2.161	1.47	< 0.001	< 0.001	< 0.002	< 0.001	< 0.002	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	-	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.01	< 0.001	< 0.001	< 0.01
EICE LAKE	4A	FATHEADS	0.533	2.177	3.98	< 0.001	< 0.001	< 0.002	< 0.001	< 0.002	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	-	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.01	< 0.001	< 0.001	< 0.01
EICE LAKE	5	ANNELIDS	1.330	2.361	1.67	< 0.001	< 0.001	< 0.002	< 0.001	< 0.002	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	-	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.01	< 0.001	< 0.001	< 0.01
EICE LAKE	5A	FATHEADS	1.004	5.673	3.78	< 0.001	< 0.001	< 0.002	< 0.001	< 0.002	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	-	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.01	< 0.001	< 0.001	< 0.01
EICE LAKE	6	ANNELIDS	1.670	2.256	1.37	< 0.001	0.002	< 0.003	0.000	< 0.002	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	-	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.01	< 0.001	< 0.001	< 0.01
EICE LAKE	6A	FATHEADS	0.756	5.290	3.21	< 0.001	< 0.001	< 0.002	0.003	< 0.002	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	-	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.01	< 0.001	< 0.001	0.05
EICE LAKE	12	ANNELIDS	1.047	2.213	1.23	< 0.001	< 0.001	< 0.002	< 0.001	< 0.002	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	-	< 0.001	0.017	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.01	< 0.001	< 0.001	< 0.01
EICE LAKE	12A	FATHEADS	1.016	3.987	3.06	< 0.001	< 0.001	< 0.002	< 0.001	< 0.002	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	-	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.01	< 0.001	< 0.001	< 0.01
EICE LAKE	8	ANNELIDS	1.562	2.588	1.23	< 0.001	< 0.001	< 0.002	< 0.001	< 0.002	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	-	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.01	< 0.001	< 0.001	< 0.01
EICE LAKE	8A	FATHEADS	0.683	3.204	3.48	< 0.001	< 0.001	< 0.002	< 0.001	< 0.002	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	-	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.01	< 0.001	< 0.001	< 0.01
EICE LAKE	9	ANNELIDS	1.331	1.690	1.32	< 0.001	< 0.001	< 0.002	< 0.001	< 0.002	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	-	0.007	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.01	< 0.001	< 0.001	< 0.01
EICE LAKE	9C	FATHEADS	0.903	3.707	3.68	< 0.001	< 0.001	< 0.002	< 0.001	< 0.002	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	-	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.01	< 0.001	< 0.001	< 0.01
EICE LAKE	14	ANNELIDS	1.440	2.713	1.01	< 0.001	< 0.001	< 0.003	< 0.004	< 0.002	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	-	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.01	< 0.001	< 0.001	< 0.01
EICE LAKE	14A	FATHEADS	1.461	4.961	3.87	< 0.001	< 0.001	0.006	< 0.004	< 0.002	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	-	< 0.001	< 0.001	0.030	< 0.001	< 0.001	< 0.001	< 0.001	< 0.01	< 0.001	< 0.001	< 0.01
EICE LAKE	7	ANNELIDS	1.470	2.170	1.50	< 0.001	< 0.001	< 0.003	< 0.004	< 0.002	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	-	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.01	< 0.001	< 0.001	< 0.01
EICE LAKE	7A	FATHEADS	0.467	2.164	3.04	< 0.001	< 0.001	< 0.003	< 0.004	< 0.002	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	-	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.01	< 0.001	< 0.001	< 0.01
EICE LAKE	10	ANNELIDS	1.560	2.207	1.30	< 0.001	< 0.001	< 0.002	< 0.004	< 0.002	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	-	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.01	< 0.001	< 0.001	< 0.01
EICE LAKE	10A	FATHEADS	0.994	3.260	3.27	< 0.001	< 0.001	< 0.002	0.003	< 0.002	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	-	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.01	< 0.001	< 0.001	< 0.01
EICE LAKE	11	ANNELIDS	1.161	2.671	1.20	< 0.001	< 0.001	< 0.002	< 0.004	< 0.002	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	-	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.01	< 0.001	< 0.001	< 0.01
EICE LAKE	11A	FATHEADS	2.077	5.990	2.68	< 0.001	< 0.001	< 0.002	< 0.004	< 0.002	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	-	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.01	< 0.001	< 0.001	0.04

KEY: < Less than detection limit
- no data

Table 20: In-Place Pollutants Program
Sediment Bioassay Bioaccumulation Results: Chlorinated Aromatics
Rice Lake - Otonabee R. 1987
UNITS: ug/g wet weight (Not corrected for gut content)

Location	Station	Organism	Hexachloro -ethane	135-TCB	124-TCB	Hexachloro -butadiene	123-TCB	245-TCT	236-TCT	1235-TCB	1245-TCB	26a-TCT	1234-TCB	Pentachloro benzene	Octachloro styrene	Toxaphene
RICE LAKE	CONTROL	MAYFLIES	< 0.001	< 0.010	< 0.01	< 0.001	< 0.005	-	-	< 0.001	< 0.001	< 0.01	0.012	0.031	-	< 0.01
RICE LAKE	CONTROL B	FATHEADS	< 0.001	< 0.010	< 0.01	< 0.001	< 0.005	-	-	< 0.001	< 0.001	< 0.01	0.015	< 0.001	-	< 0.01
RICE LAKE	1S	MAYFLIES	< 0.001	< 0.010	< 0.01	0.002	< 0.005	-	-	< 0.001	< 0.001	< 0.01	0.008	0.031	-	< 0.01
RICE LAKE	1SA	FATHEADS	< 0.001	< 0.010	< 0.01	< 0.001	< 0.005	-	-	< 0.001	< 0.001	< 0.01	< 0.001	< 0.001	-	< 0.01
RICE LAKE	1	MAYFLIES	< 0.001	< 0.010	< 0.01	< 0.001	< 0.005	-	-	< 0.001	< 0.001	< 0.01	0.005	< 0.001	-	< 0.01
RICE LAKE	1C	FATHEADS	< 0.001	< 0.010	< 0.01	< 0.001	< 0.005	-	-	< 0.001	< 0.001	< 0.01	< 0.001	< 0.001	-	< 0.01
RICE LAKE	3	MAYFLIES	< 0.001	0.006	< 0.01	0.002	< 0.005	-	-	< 0.001	< 0.001	< 0.01	< 0.001	< 0.001	-	< 0.01
RICE LAKE	3A	FATHEADS	< 0.001	< 0.010	< 0.01	0.020	< 0.005	-	-	< 0.001	< 0.001	< 0.01	< 0.001	< 0.001	-	< 0.01
RICE LAKE	4	MAYFLIES	< 0.001	< 0.010	< 0.01	0.003	< 0.005	-	-	< 0.001	< 0.001	< 0.01	0.006	0.009	-	< 0.01
RICE LAKE	4A	FATHEADS	< 0.001	< 0.010	< 0.01	0.004	< 0.005	-	-	< 0.001	< 0.001	< 0.01	< 0.001	< 0.001	-	< 0.01
RICE LAKE	5	MAYFLIES	< 0.001	< 0.010	< 0.01	< 0.001	< 0.005	-	-	< 0.001	< 0.001	< 0.01	< 0.001	< 0.001	-	< 0.01
RICE LAKE	5A	FATHEADS	< 0.001	< 0.010	< 0.01	0.002	< 0.005	-	-	< 0.001	< 0.001	< 0.01	< 0.001	< 0.001	-	< 0.01
RICE LAKE	8	MAYFLIES	< 0.001	< 0.010	< 0.01	< 0.001	< 0.005	-	-	< 0.001	< 0.001	< 0.01	0.004	< 0.001	-	< 0.01
RICE LAKE	8A	FATHEADS	< 0.001	< 0.010	< 0.01	< 0.001	< 0.005	-	-	< 0.001	< 0.001	< 0.01	0.004	0.020	-	< 0.01
RICE LAKE	12	MAYFLIES	< 0.001	< 0.010	< 0.01	< 0.001	< 0.005	-	-	< 0.001	< 0.001	< 0.01	< 0.001	< 0.001	-	< 0.01
RICE LAKE	12A	FATHEADS	< 0.001	0.060	< 0.01	< 0.001	< 0.005	-	-	< 0.001	< 0.001	< 0.01	< 0.001	< 0.001	-	< 0.01
RICE LAKE	6	MAYFLIES	< 0.001	< 0.010	< 0.01	< 0.001	< 0.005	-	-	< 0.001	< 0.001	< 0.01	0.013	< 0.001	-	< 0.01
RICE LAKE	6A	FATHEADS	< 0.001	< 0.010	< 0.01	< 0.001	< 0.005	-	-	< 0.001	< 0.001	< 0.01	< 0.001	< 0.001	-	< 0.01
RICE LAKE	9	MAYFLIES	< 0.001	< 0.010	< 0.01	< 0.001	< 0.005	-	-	< 0.001	< 0.001	< 0.01	< 0.001	< 0.001	-	< 0.01
RICE LAKE	9C	FATHEADS	< 0.001	< 0.010	< 0.01	< 0.001	< 0.005	-	-	< 0.001	< 0.001	< 0.01	< 0.001	< 0.001	-	< 0.01
RICE LAKE	14	MAYFLIES	< 0.001	< 0.010	< 0.01	< 0.001	< 0.005	-	-	< 0.001	< 0.001	< 0.01	< 0.001	< 0.001	-	< 0.01
RICE LAKE	14A	FATHEADS	< 0.001	< 0.010	< 0.01	< 0.001	< 0.005	-	-	< 0.001	< 0.001	< 0.01	0.003	< 0.001	-	< 0.01
RICE LAKE	7	MAYFLIES	< 0.001	< 0.010	< 0.01	< 0.001	< 0.005	-	-	< 0.001	< 0.001	< 0.01	< 0.001	< 0.001	-	< 0.01
RICE LAKE	7A	FATHEADS	< 0.001	< 0.010	< 0.01	< 0.001	< 0.005	-	-	< 0.001	< 0.001	< 0.01	0.005	< 0.001	-	< 0.01
RICE LAKE	10	MAYFLIES	0.006	< 0.010	< 0.01	< 0.001	< 0.005	-	-	< 0.001	< 0.001	< 0.01	0.027	< 0.001	-	< 0.01
RICE LAKE	10A	FATHEADS	0.009	< 0.010	< 0.01	< 0.001	< 0.005	-	-	< 0.001	< 0.001	< 0.01	< 0.001	< 0.001	-	< 0.01
RICE LAKE	11	MAYFLIES	< 0.001	< 0.010	< 0.01	< 0.001	< 0.005	-	-	< 0.001	< 0.001	< 0.01	0.015	< 0.001	-	< 0.01
RICE LAKE	11A	FATHEADS	< 0.001	< 0.010	< 0.01	< 0.001	< 0.005	-	-	< 0.001	< 0.001	< 0.01	< 0.001	< 0.001	-	< 0.01

KEY: < Less than detection limit
- No data

TABLE 21: Correlation Coefficients (Spearman Rank) for Sediment Metals and Organic Carbon, for Sediment Metals and Corresponding Invertebrate Tissue Levels amd Sediment Metals and Solvent Extractables (significance level in parentheses).

	Sediment TOC	Biota* Metal	Solvent Extractables
sediment aluminum	.5099 (.0564)	**.6294** (.0369)	.4462 (.0950)
sediment arsenic	.4186 (.1173)	.5094 (.0911)	**.5929** (.0265)
sediment cadmium	.2312 (.3870)	.2662 (.3773)	.4025 (.1321)
sediment chromium	.2576 (.3351)	.3853 (.2013)	.4036 (.1310)
sediment copper	-.0411 (.8776)	.5649 (.0610)	**.6607** (.0134)
sediment iron	.4337 (.1015)	.1608 (.5937)	**.5783** (.0305)
sediment lead	-.0411 (.8776)	.6133 (.0419)	**.6786** (.0111)
sediment manganese	.3020 (.2585)	-.1678 (.5778)	.4651 (.0818)
sediment mercury	.3154 (.2379)	-	.4365 (.1024)
sediment nickel	.5206 (.0514)	.3489 (.2472)	**.5448** (.0415)
sediment zinc	.0189 (.9437)	.4685 (.1202)	**.5835** (.0290)

* Biota = Invertebrate tissue levels of the corresponding metal (wet weight not corrected for gut contents)

Correlations significant at the 95% levels appear in bold type.

TABLE 22: Correlation Coefficients (Spearman Rank) for Sediment PAHs and Organic Carbon and for Sediment PAHs and Solvent Extractables (significance level in parentheses).

	Sediment TOC	Solvent** Extractables
Dibenzo(a,h)anthracene	-.6502 (.1112)	.1970 (.6294)
Benzo(g,h,i)perylene	**-.8571** (.0358)	.1786 (.6618)
Naphthalene	-.3563 (.3827)	.4900 (.2301)
Acenaphthylene	-.7572 (.0636)	-.0455 (.9131)
Acenaphthene	-.3563 (.3827)	.4900 (.2301)
Fluorene	-.3563 (.3827)	.4900 (.2301)
Phenanthrene	-.7783 (.0566)	.0371 (.9277)
Anthracene	-.7783 (.0566)	.0371 (.9277)
Fluoranthrene	-.7857 (.0543)	.1786 (.6618)
Pyrene	-.7857 (.0543)	.1786 (.6618)
Benzo(a)anthracene	**-.9286** (.0229)	-
Chrysene	-.9286 (.0229)	-
Benzo(k)fluoranthene	-.8214 (.0442)	.1429 (.7264)
Benzo(b)fluorene	-.8214 (.0442)	.1429 (.7264)
Benzo(a)pyrene	-.9286 (.0229)	-
Indeno(1,2,3-cd)pyrene	-.8571 (.0358)	.1786 (.6618)

Correlations significant at the 95% levels appear in bold type.

TABLE 23: Correlation Coefficients (Spearman Rank) for Sediment Geochemical Fractions and Invertebrate Tissue Level (all calculations based on wet weight) (significance level in parentheses).

	IW	F1	F2	F3	F4	F3+F4	Sum F1-F4	Res	Bulk
biota aluminum	-.4222 (.1614)	.4825 (.1095)	-.3846 (.2021)	**.8441** (.0051)	**.7343** (.0149)	**.8531** (.0047)	**.7972** (.0082)	.9161 (.0024)	.6294 (.0369)
biota arsenic	-3737 (.2152)	-	.2584 (.3914)	.4479 (.1374)	.2600 (.3885)	.2749 (.3618)	-	.4361 (.1481)	.5094 (.0911)
biota cadmium	-	-	-	.5322 (.0776)	**.6397** (.0339)	**.7160** (.0176)	-	.3057 (.3106)	.2662 (.3773)
biota chromium	-	.2908 (.3348)	.5199 (.0847)	**.8021** (.0078)	.5775 (.0555)	**.7912** (.0087)	**.7912** (.0087)	**.7399** (.0141)	.3853 (.2013)
biota copper	-.2570 (.3940)	-	-.3930 (.1924)	**.6095** (.0432)	**.6257** (.0380)	**.6503** (.0310)	-	.5583 (.0641)	.5649 (.0610)
biota iron	-.4685 (.1202)	-.1368 (.6499)	-.0595 (.8434)	.5455 (.0704)	.3923 (.1932)	.5175 (.0861)	.4615 (.1258)	.1818 (.5465)	.1608 (.5937)
biota lead	-	**.6504** (.0310)	.2002 (.5067)	**.8748** (.0037)	.2002 (.4979)	**.8748** (.0037)	**.9123** (.0025)	-	**.6133** (.0419)
biota manganese	-.1888 (.5312)	.1538 (.6099)	.4056 (.1786)	**.6084** (.0436)	.4789 (.1122)	**.6294** (.0369)	.4825 (.1095)	.2517 (.4037)	-.1678 (.5778)
biota nickel	.0912 (.7623)	.1396 (.6433)	-	**.6867** (.0227)	-	-	-	**.7780** (.0099)	.3489 (.2472)
biota zinc	-.0407 (.8927)	.5404 (.0731)	.2727 (.3657)	.3846 (.2021)	.3803 (.2072)	.3566 (.2369)	.3427 (.2558)	.5519 (.0672)	.4685 (.1202)

Correlations significant at the 95% level appear in bold type.

TABLE 24. DISTRIBUTION, DENSITY, AND BIOMASS ESTIMATES OF MAJOR MACROBENTHIC TAXA, OTONABEE RIVER AND RICE LAKE, JUNE, 1987.

All values are expressed per square meter.

	Station 0015		Station 0001		Station 0003		Station 0004		Station 0005		Station 0008		Station 0012	
	Average # Organisms	Biomass (gms)	Average # Organisms	Biomass (gms)	Average # Organisms	Biomass (gms)	Average # Organisms	Biomass (gms)	Average # Organisms	Biomass (gms)	Average # Organisms	Biomass (gms)	Average # Organisms	Biomass (gms)
ARTHROPODA														
Class Insecta														
O. Odonata											38	0.0036		
O. Ephemeroptera					38	0.3424			46	1.6291	31	0.1019		
O. Trichoptera							15	0.0247	84	0.0666				
O. Coleoptera							245	0.1172	483	0.1188				
O. Diptera														
F. Chironomidae	276	0.2654	590	0.3878	3,762	3.6154	965	1.3068	192	0.0775	3,861	5.5980	617	1.3568
F. Ceratopogonidae							15	0.0249	69	0.0115				
Class Crustacea														
O. Amphipoda							199	0.2295	299	0.1891	92	0.1693	30	0.0359
O. Isopoda					7	0.0161			15	0.0198	107	0.0743	19	0.0086
MOLLUSCA														
Class Gastropoda											31	0.0923		
Class Pelecypoda			46	0.2741	199	0.1505					77	0.0640	4	0.0004
ANNELIDA														
Class Hirudinea			15	0.0835			15							
Class Oligochaeta	199	0.0312	7,944	7.0310	598	0.2546	1,655	0.4786	1,862	0.9132	1,394	0.8136	322	0.3338
TOTAL # ORGANISMS	475		8,595		4,604		3,109		3,050		5,631		992	
TOTAL BIOMASS		0.2966		7.7764		4.3790		2.1817		3.0256		6.9170		1.7355
CORRECTED BIOMASS (+ 10%)		0.3263		8.5540		4.8169		2.3999		3.3282		7.6087		1.9091

TABLE 24. Cont'd

All values are expressed per square meter.

	Station 0006		Station 0009		Station 0014		Station 0007		Station 0010		Station 0011		Station 0013	
	Average # Organisms	Biomass (gms)	Average # Organisms	Biomass (gms)	Average # Organisms	Biomass (gms)	Average # Organisms	Biomass (gms)	Average # Organisms	Biomass (gms)	Average # Organisms	Biomass (gms)	Average # Organisms	Biomass (gms)
ARTHROPODA														
Class Insecta														
O. Odonata														
O. Ephemeroptera														
O. Trichoptera														
O. Coleoptera														
O. Diptera					4									
F. Chironomidae	877	1.1768	996	1.4852	548	2.2161	578	0.7766	418	0.9262	625	0.5056	961	1.4192
F. Ceratopogonidae							8	0.0127						
Class Crustacea	4													
O. Amphipoda			31	0.0065	34	0.0193	58	0.0303	15	0.0292			100	0.0650
O. Isopoda	4													
MOLLUSCA														
Class Gastropoda			8											
Class Pelecypoda			8	0.0189	46	0.0203								
ANNELIDA									38	0.0224	4	0.0037		
Class Hirudinea			15	0.0596										
Class Oligochaeta	184	0.1161	835	0.8313	260	0.3349	19	0.0330			15	0.0621		
							146	0.0405	100	0.0599	126	0.0244	123	0.0260
TOTAL # ORGANISMS	1,069		1,839		892		809		571		770		1,184	
TOTAL BIOMASS		1.2929		2.4015		2.5906		0.8931		1.0377		0.5958		1.5102
CORRECTED BIOMASS (+ 10%)		1.4222		2.6416		2.8497		0.9824		1.1415		0.6554		1.6613

TABLE 25. DENSITY AND DISTRIBUTION OF MACROBENTHIC TAXA OF THE OTONABEE RIVER AND RICE LAKE, JUNE, 1987.

SPECIES	STATION NUMBER (#/m2)													
	15	1	3	4	5	8	12	6	9	14	7	10	11	13
EPHEMEROPTERA														
Ephemeridae														
Hexagenia limbata			38		38					19				
TRICHOPTERA														
Polycentropodidae:														
Phylocentropus sp					115									
DIPTERA														
Chironomidae:														
Chironominae														
Chironomus sp.								383						1073
Chironomus plumosus grp	77								38	364		77	441	
Cladopelma sp.	115	77												
Cryptochironomus sp.	38		4137	306		3064	594				77			153
Dicrotendipes sp.									38		38			
Endochironomus sp.				153		77			306					
Glyptotendipes sp.					38				115		38			
Parachironomus sp.							19		38					
Cladotanytarsus sp				77					115					
Tanytarsus sp.	77							249			230	38		230
Orthocladiinae														
Cricotopus festivellus grp														
Epoicocladius sp.				77										
Psectrocladius sp.					38				153					
Prodiamesinae:														
Monodiamesa depectinata									115			38		
Tanypodinae										96				
Coelotanypus sp.										96	268	192	38	
Thienemannimyia grp.				77										
Procladius sp.		460	230	306		77	57	153						
Ceratopogonidae														
Palpomyia sp.grp.		460			77									
COLEOPTERA														
Elmidae														
Dubiraphia sp.				153	728									
AMPHIPODA														
Gammaridae														
Gammarus fasciatus				153	268	153	38	19	38	38	38			77
ISOPODA														
Asellidae														
Asellus								19						
GASTROPODA						77	19							

Valvatidae														
Valvata sincera									38					
PELECYPODA														
Sphaeriidae														
Sphaerium sp.						77								
Pisidium casertanum			268							77		38		
HIRUDINEA														
Helobdella stagnalis											38			
Dina sp.													19	
OLIGOCHAETA														
Tubificidae														
Limnodrilus hoffmeisteri								19	268	115				
L.udekemianus		3984	77	613	1571	613	96							
Potamothrix vejdovskyi			77	77										
Aulodrilus americanus				77									38	
A. pleuriseta			38	77									19	
Immatures with capilliform setae								19					19	
Immatures without capilliform setae	77	3984	383	1456	1226	1149	115	19	268	249	38		19	
Naididae:														
Arcteonais lomondi								38			153		19	77
Nais sp.							57						57	
Stylaria lacustris	115						38					77		
Pristinella jenkinae														
Total Number of Organisms	499	8505	5248	3679	4099	5287	1033	918	1530	1054	918	460	650	1610
Species Diversity (H')	2.505	1.312	1.242	2.943	2.189	1.797	2.153	2.236	3.179	2.551	2.697	2.279	1.761	1.531
Species Richness (S.R.)	0.805	0.332	0.817	1.583	0.962	0.816	1.153	1.173	1.5	1.006	1.173	0.815	1.081	0.542
Evenness (J')	0.969	0.656	0.414	0.773	0.691	0.599	0.679	0.705	0.887	0.85	0.851	0.882	0.587	0.66